AD-A016 392

IMPACT OF EXTERNAL ENVIRONMENTAL FACTORS ON MINUTEMAN III INERTIAL GUIDANCE SYSTEM (NS-20) FAILURES

Gerald L. Clemons, et al

Air Force Institute of Technology
Wright-Patterson Air Force Base, Ohio

August 1975

DISTRIBUTED BY:

NTIS
National Technical Information Service
U. S. DEPARTMENT OF COMMERCE

AF INSTITUTE OF TECHNOLOGY

UNITED STATES AIR FORCE

AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

IMPACT OF EXTERNAL ENVIRONMENTAL FACTORS ON MINUTEMAN III INERTIAL GUIDANCE SYSTEM (NS-20) FAILURES

Gerald L. Clemons, Major, USAF
Chris A. Schell, Captain, USAF

SLSR 27-75B

USAF SCN 75-20B AFIT Control Number SLSR 27-75B

AFIT RESEARCH ASSESSMENT

The purpose of this questionnaire is to determine the potential for current and future applications of AFIT thesis research. Please return completed questionnaires to: AFIT/SLGR (Thesis Feedback), Wright-Patterson AFB, Ohio 45433.

1. Did this research contribute to a current Air Force project?

   a. Yes b. No

2. Do you believe this research topic is significant enough that it would have been researched (or contracted) by your organization or another agency if AFIT had not researched it?

   a. Yes b. No

3. The benefits of AFIT research can often be expressed by the equivalent value that your agency received by virtue of AFIT performing the research. Can you estimate what this research would have cost if it had been accomplished under contract or if it had been done in-house in terms of manpower and/or dollars?

   a. Man-years ________ $ ________ (Contract).

   b. Man-years ________ $ ________ (In-house).

4. Often it is not possible to attach equivalent dollar values to research, although the results of the research may, in fact, be important. Whether or not you were able to establish an equivalent value for this research (3 above), what is your estimate of its significance?

   a. Highly Significant b. Significant c. Slightly Significant d. Of No Significance

5. Comments:

ia

________________________ ________________________
Name and Grade Position

________________________ ________________________
Organization Location

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: SLSR 27-75B	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): IMPACT OF EXTERNAL ENVIRONMENT FACTORS ON MINUTEMAN III INERTIAL GUIDANCE SYSTEM (NS-20) FAILURES	5. TYPE OF REPORT & PERIOD COVERED: Master's Thesis
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Gerald L. Clemons, Major, USAF; Chris A. Schell, Captain, USAF	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Graduate Education Division, School of Systems and Logistics, Air Force Institute of Technology, WPAFB, OH	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: Department of Research and Communicative Studies (SLGR), AFIT/SLGR, WPAFB, OH 45433	12. REPORT DATE: August 1975
	13. NUMBER OF PAGES: ~~209~~ 216
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report): UNCLASSIFIED
	15a. DECLASSIFICATION DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Approved for public release IAW AFR 190-17

Jerry C. Hix

JERRY C. HIX, Captain, USAF
Director of Information, AFIT

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

EXTERNAL ENVIRONMENTAL FACTORS
MINUTEMAN III
INERTIAL GUIDANCE SYSTEM
MISSLES
NS-20

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Thesis Chairman: R. R. Calkins, Lieutenant Colonel, USAF

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

This study is a preliminary search to determine if a relationship exists between Minuteman III Guidance System (NS-20) failures and the external environmental factors of temperature, wind speed, wind direction, humidity, and barometric pressure. Multiple regression analysis was used to determine what degree of relationship, if any, existed between NS-20 failures and several combinations of environmental factors. The search was extended to determine whether or not a relationship existed between external environmental factors and the failure of subcomponents of the NS-20, i.e., the Digital Computer Unit (DCU) and the Pendulous Integrating Gyroscopic Assembly (PIGA). Environmental conditions existing at the time of failure and prior to the time of failure were included. The strongest relationship was found to exist between failures of the DCU and a limited combination of environmental factors existing at the time of failure (humidity, barometric pressure, wind speed, and wind direction), and the rate-of-temperature change existing prior to the time of failure. The researchers concluded the relationship was significant enough to warrant further study.

ic

SLSR 27-75B

IMPACT OF EXTERNAL ENVIRONMENT FACTORS ON MINUTEMAN III INERTIAL GUIDANCE SYSTEM (NS-20) FAILURES

A Thesis

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Logistics Management

By

Gerald L. Clemons, BA
Major, USAF

Chris A. Schell, BA
Captain, USAF

August 1975

id

This thesis, written by

Major Gerald L. Clemons

and

Captain Chris A. Schell

has been accepted by the undersigned on behalf of the faculty of the School of Systems and Logistics in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN LOGISTICS MANAGEMENT

DATE: 13 August 1975

COMMITTEE CHAIRMAN

ACKNOWLEDGEMENTS

The authors pay special recognition to Mr. Neukuckatz, Space and Missile Systems Organization and to Lieutenant Clark, Detachment 13, 3rd Weather Wing, for their invaluable assistance in securing the data for this study. A special "thanks" is extended to Lynda Clemons who spent so many frustrating hours typing and retyping our draft copies.

TABLE OF CONTENTS

Page

ACKNOWLEDGEMENTS iii

LIST OF FIGURES vii

Chapter

I. INTRODUCTION 1

STATEMENT OF THE PROBLEM 1

DEFINITIONS 1

JUSTIFICATION OF RESEARCH 3

SCOPE 12

SUMMARY 13

FAILURE RATE AND TIME BETWEEN SUCCESSIVE FAILURES 14

OBJECTIVE 14

LIMITATIONS 14

RESEARCH HYPOTHESIS 14

OVERVIEW 15

II. RESEARCH METHODOLOGY 16

INTRODUCTION 16

RESEARCH DESIGN 16

MULTIPLE REGRESSION ANALYSIS 20

CRITERIA TEST 22

Chapter Page

III. DATA CONVERSION AND PROCESSING 25

INTRODUCTION 25

NS-20 FAILURE DATA 26

ENVIRONMENTAL DATA 29

DATA PROCESSING--STEP ONE 33

DATA PROCESSING--STEP TWO 39

SUMMARIZATION OF DATA 44

ASSUMPTIONS 49

LIMITATIONS 49

SUMMARY 49

IV. DATA ANALYSIS AND TESTING OF HYPOTHESIS 50

INTRODUCTION 50

ANALYSIS OF NS-20 NON-STRATIFIED POPULATION 50

ANALYSIS OF NS-20 STRATIFIED POPULATION 53

COMPUTATION OF EQUATIONS 53

ANALYSIS OF THE OUTPUT 58

ANALYSIS OF GROUP ONE EQUATIONS 60

ANALYSIS OF GROUP TWO EQUATIONS 64

ANALYSIS OF GROUP THREE EQUATIONS 76

TESTING OF HYPOTHESIS 83

V. CONCLUSIONS AND RECOMMENDATIONS 91

CONCLUSIONS 92

RECOMMENDATIONS 94

Page

APPENDICES 97

A. FAILURE GROUP ONE (ALL NS-20 FAILURES) VERSUS ENVIRONMENTAL GROUPS A, B, AND C 100

A-1. FAILURE GROUP ONE (ALL NS-20 FAILURES) VERSUS ENVIRONMENTAL GROUP A 102

A-2. FAILURE GROUP ONE (ALL NS-20 FAILURES) VERSUS ENVIRONMENTAL GROUP B 104

A-3. FAILURE GROUP ONE (ALL NS-20 FAILURES) VERSUS ENVIRONMENTAL GROUP C 111

B. FAILURE GROUP TWO (DCU FAILURES) VERSUS ENVIRONMENTAL GROUPS A, B, AND C 118

B-1. FAILURE GROUP TWO (DCU FAILURES) VERSUS ENVIRONMENTAL GROUP A 120

B-2. FAILURE GROUP TWO (DCU FAILURES) VERSUS ENVIRONMENTAL GROUP B 122

B-3. FAILURE GROUP TWO (DCU FAILURES) VERSUS ENVIRONMENTAL GROUP C 129

C. FAILURE GROUP THREE (PIGA FAILURES) VERSUS ENVIRONMENTAL GROUPS A, B, AND C 166

C-1. FAILURE GROUP THREE (PIGA FAILURES) VERSUS ENVIRONMENTAL GROUP A 168

C-2. FAILURE GROUP THREE (PIGA FAILURES) VERSUS ENVIRONMENTAL GROUP B 170

C-3. FAILURE GROUP THREE (PIGA FAILURES) VERSUS ENVIRONMENTAL GROUP C 177

D. COMPUTER PROGRAMS USED TO CONVERT RAW DATA TO USABLE FORM 196

D-1. COMPUTER PROGRAM MOD1 198

D-2. COMPUTER PROGRAM MOD2 200

SELECTED BIBLIOGRAPHY 205

LIST OF FIGURES

Figure		Page
1.	Missile Component Location	5
2.	NS-20 Missile Guidance Set	6
3.	Wing VI Layout	8
4.	Variable Combinations	19
5.	Population of NS-20 Failure Data Grand Forks AFB, Calendar Year 1973	27
6.	Sample NS-20 Failure Data	30
7.	Sample Weather Data	32
8.	Sample Data Entry	34
9.	Dewpoint/Humidity Conversion Chart	38
10.	Sample Temperature Input	39
11.	File CLSC1	45
12.	File TEMP	46
13.	Summary of Multiple Regression Equations	51
14.	Sample BMD02R Output	55
15.	Group One Equations vs. Environmental Groups A, B, and C	61
16.	Failure Group One vs. Environmental Group B	63
17.	Failure Group One vs. Environmental Group C	65
18.	Group Two Equations vs. Environmental Groups A, B, and C	66
19.	Failure Group Two vs. Environmental Group B	69

Figure Page

20. Failure Group Two vs. Environmental Group C 71

21. Time of Day vs. DCU Failure Rate 72

22. Month of Failure vs. DCU Failure Rate 73

23. Contribution of Average Rate-of-Temperature Change Variable to R^2 for DCU Failures . . . 74

24. Group Three Equations vs. Environmental Groups A, B, and C 77

25. Failure Group Three vs. Environmental Group B 79

26. Failure Group Three vs. Environmental Group C 82

27. Summary of Multiple Regression Equations . . . 87

28. Equations Producing R^2 Values of .35 and Above 88

29. F-Distribution Values for Appendices A, B, and C 99

CHAPTER I

INTRODUCTION

Statement of the Problem

Environmental control is an important part of the Minuteman weapon system. Critical temperature and humidity ranges should be maintained for the operation of the electronic equipment and the missile (7:1). The failure rate for the Minuteman III missile guidance set (NS-20) seems to be greater during the spring and fall months. Hence there is reason to believe the environmental control system for the Minuteman III weapon system is not protecting the missile and its electronic equipment from changes in the external environment (15). If there is a relationship between changes in external environmental conditions and the failure rate of the NS-20 guidance system, then action could be initiated to correct the problem and possibly reduce the number of NS-20 failures.

Definitions

Chiller Unit--a component of the environmental control system which cools a brine solution. The brine solution then cools a sodium dichromate solution which in turn cools selected components within the NS-20 guidance system (4:24).

Digital Computer Unit (DCU)--converts sensor data to stabilization and sensing signals. Converts inertial measuring unit velocity and angular attitude signals to control signals for staging, thrust termination, pre-arming, re-entry system disconnect and other flight functions. Monitors guidance control systems to provide proper response to status request messages and executes the operational ground program (25:1-4).

Failure Rate--the number of NS-20 failures that normally occur within a specified period of time. Therefore, any given failure rate may vary according to a function of time. See Chapter I, Failure Rate and Time Between Successive Failures.

Flight Control Group--the first, second and third stage motor control systems. Also includes the Propulsion System Rocket Engine for the Minuteman III missile (6:54).

Gyro Stabilized Platform--provides information concerning missile attitude acceleration and velocity to ditigal computer unit (25:1-3).

Missile Guidance Control System--the complete guidance control system consisting of the missile guidance set (NS-20) and the flight control group (25:1-2).

Missile Guidance Set Control--interpreting medium between gyro stabilized platform and digital computer unit (25:1-2).

Missile Guidance Set (NS-20)--consists of the missile guidance set control, gyro stabilized platform, digital computer unit, battery power supply, and the control and discrete amplifier assembly (25:1-2).

Pendulous Integrating Gyro Accelerometer (PIGA)--a device located in the gyro unit which detects changes in acceleration. This information is then sent to the on-board computer which then calculates the missile's velocity and the distance it has travelled (9:5).

Retest OK (RTOK)--a term used by the depot to identify a missile guidance set (NS-20) that gave failure indications and shutdown at the missile site, but functioned properly when analyzed at the depot (19).

Time Between Successive Failures (TBSF)--the time period between one NS-20 failure and the next. As the TBSF decreases/increases, the failure rate increases/decreases. See Chapter I, Failure Rate and Time Between Successive Failures.

Justification of Research

The Minuteman III guidance and control system consists of a missile guidance set (NS-20) and a flight control group (6:49-50). The guidance and control system performs both ground and in-flight functions. On the ground, the system maintains operational readiness of the site through self-testing, spatial orientation to the launch point, and automatic adjustment of navigation parameters. The

guidance and control system also processes remote commands and provides status reports on missile and launch facility equipment. During the boost phase, the guidance system performs inertial navigation, flight control, staging, and thrust termination. The primary component of the guidance and control system is the missile guidance set (NS-20). The missile guidance set is a cylindrical missile body section located forward of the propulsion system rocket engine (see Figure 1(6:54). Additionally, the missile guidance set houses the gyro-stabilized platform, missile guidance set control, digital control unit, amplifier assembly, and the battery power supply as shown in Figure 2.

When the NS-20 fails, the missile maintenance officer becomes involved. His job is to take whatever action is necessary to return the missile to alert status. Approximately 60 to 75 manhours are required to remove and replace the NS-20 (21). Only 20 to 25 manhours are required for the actual removal and replacement of the NS-20. The remainder of the time is spent in preparation and travel to and from the missile site (21). To support this task, two specially equipped vehicles are required: a maintenance van and a payload transporter (6:63-64).

The removal and replacement procedure is accomplished by a missile maintenance team composed of five highly trained technicians (21). This procedure requires

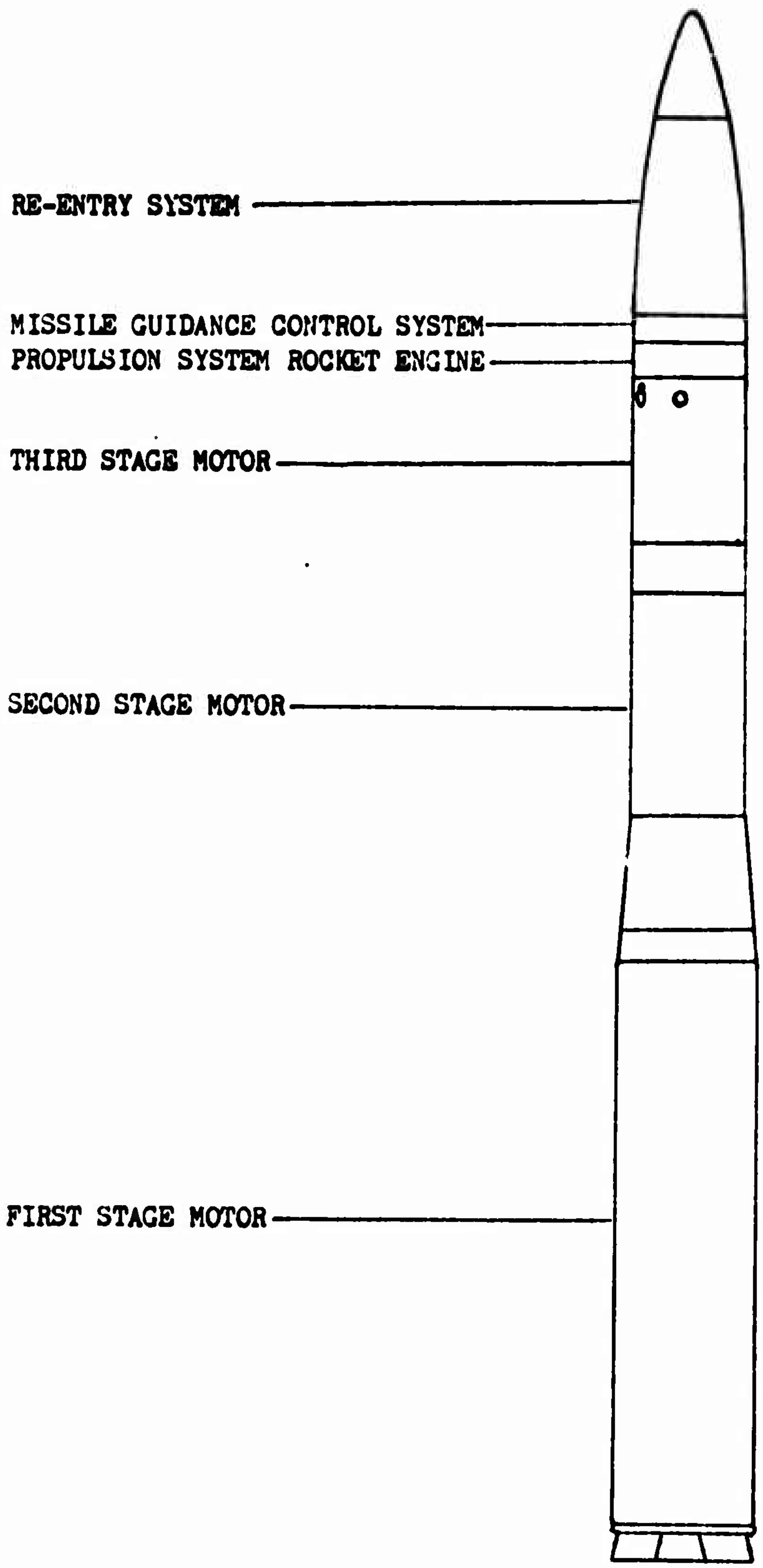


Figure 1. Missile Component Location

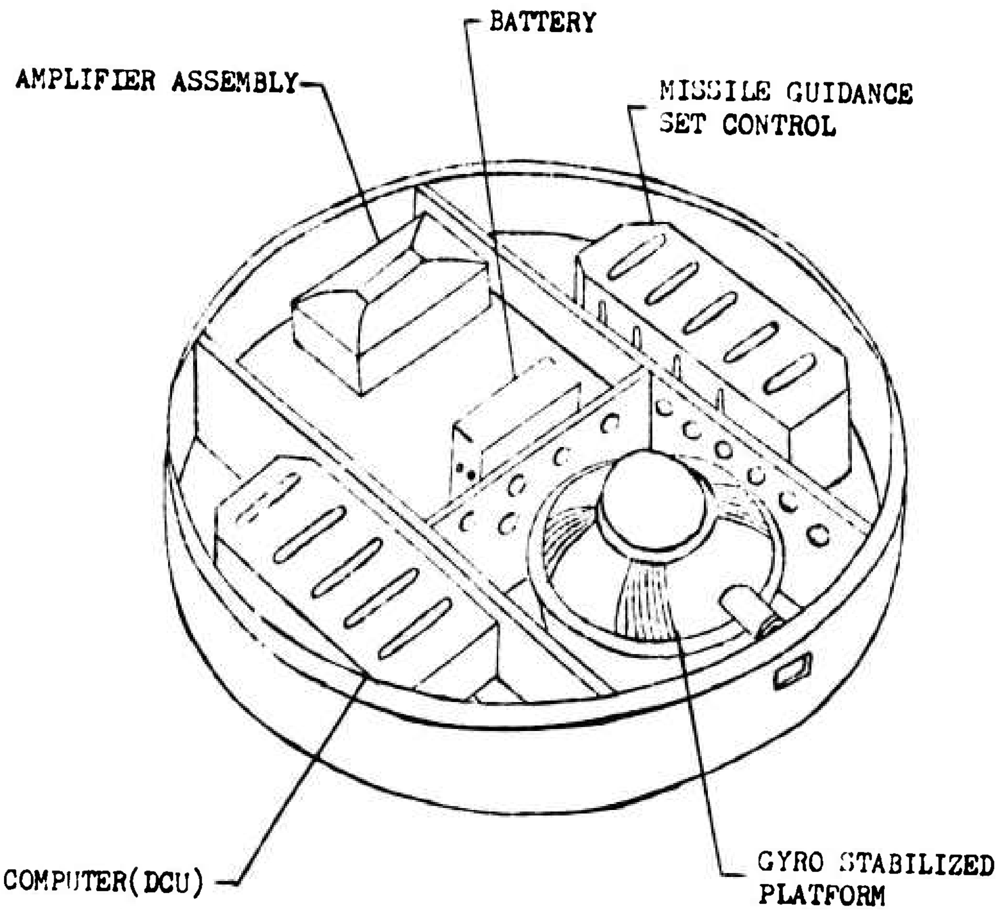


Figure 2. NS-20 Missile Guidance Set

the following sequence: (1) remove the re-entry system (warhead), (2) remove the defective NS-20 guidance system, (3) install the new NS-20 guidance system, and (4) replace the re-entry system.

The maintenance officer's task is complicated by the manner in which the Minuteman missile sites are deployed. The squadrons are dispersed over large areas. For example, the average site at Grand Forks AFB, North Dakota is approximately 75 surface miles from the support base (see Figure 3).

Another complicating factor is that all Minuteman units are either involved in or scheduled for a major modification program (1:3-3). These programs create many problems for unit maintenance personnel. One is the efficient use of test and support equipment. Since only a limited number of certain equipment items are available, maintenance organizations share these items with contractors performing weapon system modifications. At times the combined requirements of the contractor and the maintenance organization exceed available supply. Therefore, neither is able to perform in an efficient manner. The payload transporter is one of the items that is frequently in short supply (3:5).

If the failure rate of the NS-20 could be reduced, then the workload of the Minuteman maintenance organization might also be reduced as well as its requirement for

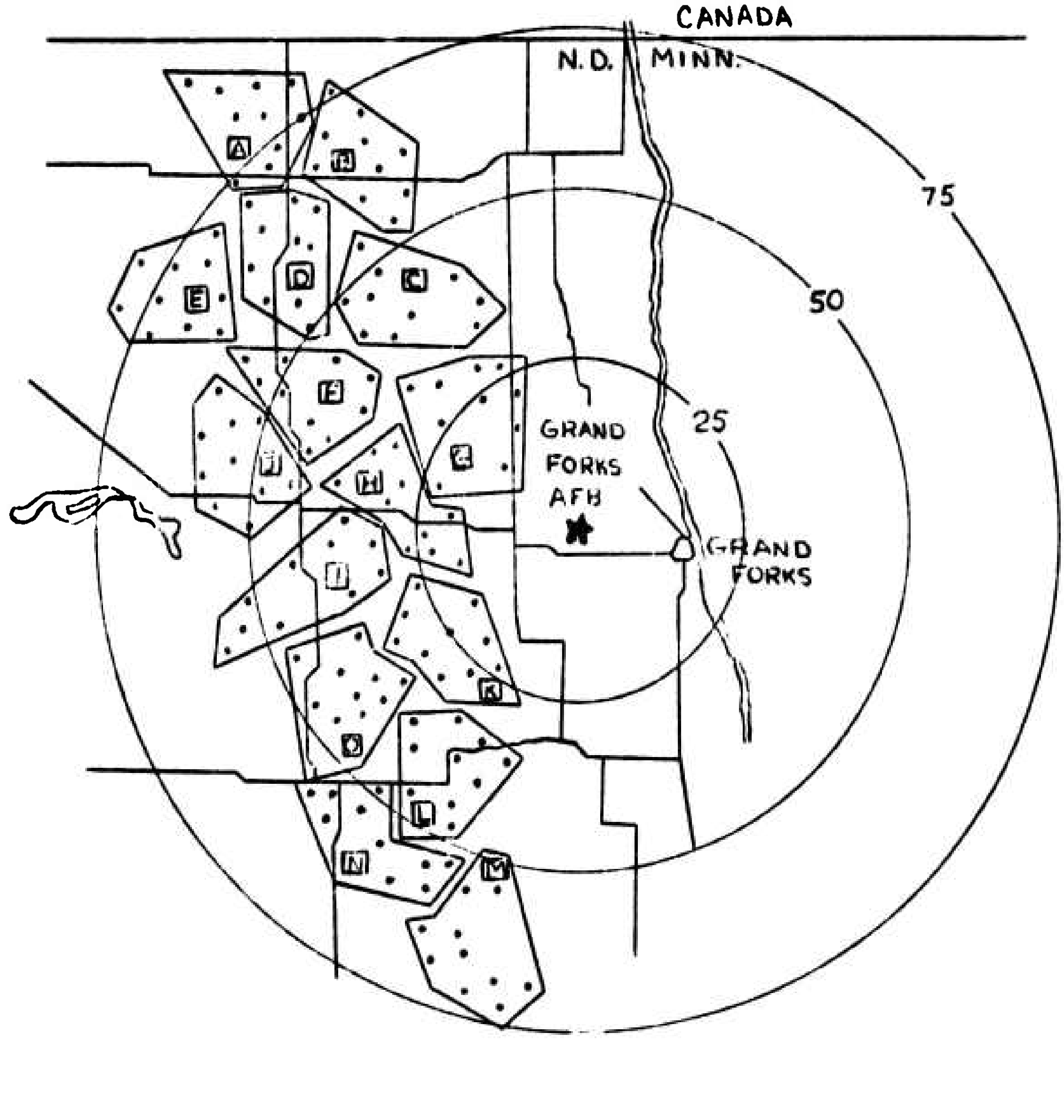


Figure 3. Wing VI Layout

critical equipment items. Reducing the NS-20 failure rate has been the goal of organizations within the Strategic Air Command (SAC), Air Force Systems Command (AFSC), and Air Force Logistics Command (AFLC) (19). While analyzing the failure data, several personnel (12; 15; 19; 20; 23; 27) have noticed that the NS-20 failure rate appears to increase during the spring and fall months.

Mr. Keith Gwylliam (15), Logistics Specialist, Ogden Air Logistics Center (ALC), believes that there is a trend toward more guidance and control system failures during the fall and spring months than at other times. He stated that the Ogden ALC anticipated an increase of failures during these times. He also thought an attempt had been made to correlate Minuteman II guidance and control system (NS-17) failures with the weather, but he was unsure of the specific details or outcome. Mr. Gwylliam indicated the Ogden ALC would be interested in a study attempting a correlation between NS-20 failures and environmental conditions.

Mr. A. Neukuckatz (19), TRW Representative, Reliability and Quality Assurance Division, Space and Missile Systems Organization, MNDR, was aware of a study that had been accomplished on the NS-17 guidance system. He did not know whether a copy was available or not, but he did remember that the study had failed to find any correlation between NS-17 failures and outside air temperature. He was

aware of several other informal studies that had also failed to find a correlation between NS-17/NS-20 failures and such things as holidays, seasons, maintenance manning levels, Santa Anna winds, etc. The studies were not documented since they consisted of scanning available data or scratch pad computations. Mr. Neukuckatz conducted a search of the TRW technical library, but failed to find any studies related to external environmental effects on guidance and control system failures. He stated that he would be glad to furnish any data the authors might require.

Mr. Robert Wallan (27), Reliability Engineer, Ogden ALC, generally agreed with Mr. Gwylliam. He offered to supply any data that might be required to support a study and recommended other sources of information.

Major Paul Pirtle (20), SAMSO/MNNG, could only recall one study in the area of environmental factors versus guidance and control system failures. It was an informal attempt to correlate NS-17 failures with the seasons. (The same study referred to by Mr. Gwylliam.) He also reported that the attempt had produced inconclusive results. Major Pirtle stated that there was a study in progress to determine the effect on Minuteman guidance systems of seismic phenomena caused by earth crustal movement due to changes in barometric pressure. However, the objective of this study was to examine accuracy rather than failure impact. He was also aware of another informal study that attempted

to correlate gyroscopic reliability with burn-in time. Again the study had inconclusive results. Major Pirtle indicated that the gyros are extremely sensitive indicators of temperature change. Slight changes in temperature will result in measurable changes in gyro bias. However, he believes this would have more of an accuracy rather than a reliability impact. Major Pirtle expressed doubt that a correlation could be found between outside air temperature changes and guidance and control failures. He believes the thermal mass of a Minuteman launcher would negate any effects of outside temperature changes.

Mr. Carroll Turbin (23), Autonetics Representative, Hq. SAC, could only recall the NS-17 study (referred to by Mr. Gwylliam and Major Pirtle) and a study conducted to determine intransit effects. He made several inquiries to autonetics personnel and to the Autonetics Technical Library. He was unable to locate any formal studies that related to environmental effects.

Lieutenant Colonel Vern Dede (12), SAC Directorate of Missile Maintenance, reported that he had requested CMSgt John Murphy, SAC Operational Engineering Squadron, F. E. Warren AFB, Wyoming, to attempt to correlate seasonal variations and transportation environmental effects with NS-17 failures. He indicated that CMSgt Murphy did not discover any correlations. Lt Col. Dede was also aware of a study in progress attempting to correlate fluctuations

in the earth's magnetic field with guidance and control system failures; the theory being that fluctuations cause spikes and surges in the commercial power serving Minuteman launch facilities. These spikes and surges may in turn have an effect on guidance and control system performance.

The belief that some NS-20 failures may be related to environmental factors appears to be based on the fact that the NS-20 is very sensitive to temperature. During ground operations the overall temperature within the NS-20 is maintained between 66 and 69 degrees Fahrenheit (8:7). Certain components, such as the gyro stabilized platform are maintained at 71.2 ± 1 degree Fahrenheit. Temperatures beyond these parameters may result in the NS-20 shutting down (4:30). The external temperature of the NS-20, i.e., the launcher temperature, is maintained between 60 and 80 degrees Fahrenheit (4:17-24).

Scope

The scope of this study is limited to NS-20 failures that occurred at Grand Forks AFB during calendar year 1973. A major modification program was in progress at Grand Forks during all of 1974; therefore that time period was not included in the study (1:3-3). F. E. Warren AFB, Wyoming, and the 564SMS, Malmstrom AFB, Montana, were not selected since they have only recently received Minuteman IIIs, and sufficient data is not available (1:3-3). Minot AFB,

North Dakota, was not considered since the 91st Strategic Missile Wing is in the process of a major modification program that will change the launcher structure, environmental control system, and the ground electronics system (2:125).

Summary

There are several theories concerning the impact of seasonal variations on the NS-20 guidance system. The impact is viewed as ranging from negligible to being responsible for some NS-20 failures (12; 15; 19; 20; 23; 27). Although there is conflicting belief on the degree of impact, the preponderance of opinion supports the concept that there may be a relationship between failures and seasonal changes. Seasonal variations in NS-20 failures, if they do exist, may be caused by any one or a combination of factors, e.g., temperature, wind speed, wind direction, humidity, barometric pressure, maintenance penetrations of the launchers for annual or semi-annual targeting changes, or maintenance manning levels. Several informal, undocumented studies have failed to discover a relationship between any of the above factors and NS-20 failures. If the environmental control and monitoring system is performing as it should, then there should be no relationship between NS-20 failures and environmental conditions. However, the belief that a relationship exists between external environmental factors and NS-20 failures still persists.

Therefore, the concept of external environmental conditions versus NS-20 failures appears to be an important candidate for study.

Failure Rate and Time Between Successive Failures

Throughout this study the term "Time Between Successive Failures" will be used instead of failure rate. The failure rate of an item refers to the number of failures that normally occur within a specified period of time. Time Between Successive Failures (TBSF) refers to the time period between one failure and the next. Thus, as the TBSF decreases/increases, the failure rate increases/decreases.

Objective

This research was designed to provide enough new knowledge to address conflicting opinion about whether different seasons and hence external environmental factors are related to the time between successive NS-20 failures.

Limitations

This study will be limited to determining whether or not there is a relationship between the TBSF of NS-20s and the external environmental factors of temperature, wind speed, wind direction, humidity and barometric pressure.

Research Hypothesis

There is a relationship between external environmental factors and the TBSF of NS-20 guidance systems.

Overview

Chapter II will present an overview of the research design. It contains a general description of NS-20 failures and external environmental conditions to be analyzed, statistical methods, and criteria used to determine the significance of results.

CHAPTER II

RESEARCH METHODOLOGY

Introduction

The relationship between the TBSF of NS-20s and external environmental conditions was examined through the use of multiple regression analysis. Multiple regression analysis was chosen since it provides a means by which the relationship between a dependent variable (TBSF) and one or more independent variables (environmental conditions) may be measured (26:232). The significance of the resulting measurement then becomes a matter of judgement. Criteria by which significance is evaluated was established by obtaining the opinions of personnel familiar with both statistical methods and the TBSF of NS-20s (26:221). The net result of the collective opinions is a criteria test by which the findings of the study were judged as significant or insignificant in terms of practical importance, rather than via the use of statistical significance alone.

Research Design

NS-20 failure modes were considered as three distinct groups. The first group contained all NS-20 failures that occurred at Grand Forks during 1973. The second group contained only those NS-20 failures that

occurred as the result of DCU malfunctions. The third group contained only those NS-20 failures that occurred as the result of PIGA malfunctions. The last two groupings (DCU and PIGA caused failures) were selected for separate analysis together since they caused approximately 66 percent of all the NS-20 failures at Grand Forks during 1973. Also, any relationship that might exist between the failure of a particular NS-20 component and environmental conditions, could possibly be obscured when NS-20 failures are analyzed as a whole.

Environmental conditions were considered in three distinct groups (A, B, and C). Group A contained the conditions that existed at the time of failure. These conditions were temperature, wind speed, wind direction, humidity, and barometric pressure. Groups B and C differed from Group A in that different temperature variables were considered. Group B used an average temperature existing for a given time prior to failure. Group C used an average rate-of-temperature change that occurred for a given time period prior to the time of failure.

Group B and C analysis was conducted due to the possibility of a delay effect of temperature on failure modes caused by the mass of Minuteman launchers. Therefore, to account for any possible delayed effect, temperature conditions were considered for several hours prior to the time of failure. The search for a relationship between

average temperature conditions (environmental Group B) and NS-20 failures covered a 72-hour period preceding the time of failure. An average was computed in six-hour periods up to the 72 hour limit. The result was twelve averages representing the average temperature during the six hours preceding failure, twelve hours preceding failure, eighteen hours preceding failure, and etc. Each average was analyzed separately to determine if a relationship exists between a particular time period/average temperature condition and the TBSF.

The search for a relationship between TBSF and rate-of-temperature change conditions (environmental group C) covered a twelve-hour period preceding the time of failure. The rate-of-temperature change was computed in one-hour increments from the time of failure up to the twelve hour limit. The result was twelve rates representing the rate-of-temperature change for one hour preceding failure, two hours preceding failure, three hours preceding failure, and etc. Each rate of change was analyzed separately to determine if a relationship existed between a particular time period/rate-of-temperature change condition and TBSF. Figure 4 is a summary of the combinations of variables that were analyzed. Each of the dependent variables was regressed with the three groups of independent variables making a total of nine different combinations.

Group	Dependent Variables (Failures)	Independent Variables (Environronmental Conditions)
1	TBSF (all causes)	Group A 1. Temperature at time of failure (TOF). 2. Wind speed at TOF. 3. Wind direction at TOF. 4. Humidity at TOF. 5. Barometric Pressure at TOF.
2	TBSF (due to DCU malfunctions)	Group B 1. Average temperature prior to failure. 2. Wind speed at TOF. 3. Wind direction at TOF. 4. Humidity at TOF. 5. Barometric pressure at TOF.
3	TBSF (due to PIGA malfunctions)	Group C 1. Rate-of-temperature change prior to failure. 2. Wind speed at TOF. 3. Wind direction at TOF. 4. Humidity at TOF. 5. Barometric pressure at TOF.

Figure 4. Variable Combinations

When significant trends or relationships were noted during the analysis, additional time periods were considered.

To maintain a conservative approach, the NS-20 failures that occurred at Grand Forks during 1973 were defined as a census of a finite population. In this context, statistical F and t-tests were not considered appropriate. Main effects were identified by data analysis consisting of descriptive statistics using simple coefficients of mathematical relationships through regression analysis or R^2; and the application of a practical criteria test rather than a statistical test. For those individuals who wish to assume the census is a representative sample from a process population, the results of F tests are included in Appendices A, B, and C.

Multiple Regression Analysis

As stated previously, multiple regression analysis was used to analyze the relationship between TBSF and external environmental conditions. The general form of the relationship is:

$$Y_m = \text{TBSF}$$

$$X_i = \text{Environmental Conditions}$$

$$Y_m = B_0 + B_1X_1 + B_2X_2 \ldots B_nX_n$$

The relationship was estimated by least squares methods for linear relationships (26:232). Once a regression relationship has been established, it may be used to derive

estimates of the dependent variable (Y_m) based on the values of the independent variable(s) (X_i). The relationship may also be used to determine the effects of the independent variables on the dependent variable (28:3). The major advantage of multiple regression analysis is that the effect of each independent variable can be measured in the context of the combined relationship with all other independent variables (18:[illegible]).

Multiple regression analysis yields an index called the coefficient of determination or R^2. The term R^2 represents the proportion of the total variability in the dependent variable, i.e., TBSF, explained by the linear regression (30:342). Total variability is equal to the explained variability plus the unexplained variability. Thus,

$$R^2 = \frac{\text{Explained Variability}}{\text{Total Variability}} \quad (29:492)$$

For example, if the total variability of the TBSF was equal to 15,672 and a linear regression resulted in an explained variability of 5,934 then:

$$R^2 = \frac{5,934}{15,672} = .378$$

This may be interpreted as meaning that 37.8 percent of the variance in the TBSF is explained by the particular combination of environmental factors (independent variables) used in the equation. Since the numerator cannot

exceed the denominator, R^2 will always be between zero and one. If R^2 equals zero, then the regression explains none of the variability, and there would be no observed relationship between the dependent variables and independent variables in the regression equation. If R^2 equals one, then the regression explains the variability perfectly. However, when the value of R^2 falls somewhere between zero and one, the significance or importance of the relationship in practical terms, between the variables becomes a matter of judgement (16:221).

Criteria Test

To construct a decision rule to use as a test of the research hypothesis, it was necessary to determine what should be considered a significant relationship in terms of practical importance between TBSF and environmental conditions. Therefore, the researchers contacted several individuals closely associated with reliability and quality control of the NS-20 missile guidance set who were also knowledgable about regression analysis. The following is a brief description of the opinions of the personnel contacted.

Both Lt. Col. W. Goodwin (14) and Mr. Neukuckatz (19), MNDR, SAMSO, declined to give any specific quantitative answers. Their reasons were that too many variables were involved to assign any significance to a specific relationship without first examining the factors being compared, the method of comparison, and the size of the

population. Lt. Col. Goodwin indicated that any findings considered insignificant by the researchers might upon further analysis by MNDR be considered significant, and conversely, findings considered significant by the researchers might be considered insignificant by MNDR.

Mr. R. Wallan (27), Ogden ALC, indicated the degree of significance depends upon the size of the population being considered. He indicated that for small populations the coefficient of determination would have to be .9 or better before he would consider the relationship significant. However, for large populations, he would consider the relationship significant if the coefficient of determination was .4 or higher.

Mr. R. Genet (13), Aerospace Guidance and Metrology Center (AGMC), Newark AFS, Ohio, agreed with Mr. Wallan's comments. However, he indicated that AGMC might assign differing degrees of significance to the researchers' findings after they had a chance to review the completed study.

As a result of the interviews, the establishment of a decision rule was delayed until after data analysis. The results of data analysis would be presented to several qualified individuals with a request for their opinion to aid in establishing a decision rule for the criteria test. The criteria test would then be applied to determine

support or nonsupport for the research hypothesis; i.e., a predicted relationship between external environmental factors and the TBSF of NS-20s.

CHAPTER III

DATA CONVERSION AND PROCESSING

Introduction

Evaluation of the research hypothesis was accomplished through the use of multiple regression analysis. During the analysis, TBSF of failure groups 1, 2, and 3 was compared with environmental groupings A, B, and C. See Figure 4, page 19. The temperature conditions examined were "temperature at failure," "average temperature prior to failure," and "average rate-of-temperature change prior to failure." These conditions are explained in detail in this chapter under the section titled "Environmental Variables." To complete the analysis, it was necessary to know the hourly weather observations at Grand Forks from 30 December 1972 to 28 December 1973. It was also necessary to know the date, time and cause of failure for every NS-20 that failed at Grand Forks during calendar year 1973. Following is a discussion of the source, validity, and collection of NS-20 failure data, environmental data, and the processing that was necessary to prepare both sets of data for use in multiple regression analysis.

NS-20 Failure Data

Universe

The universe of NS-20 guidance systems have been operationally deployed on Minuteman III missiles since February 1970 (2:80). NS-20s are presently operationally deployed on 500 Minuteman IIIs: 150 at Minot AFB, North Dakota; 150 at Grand Forks AFB, North Dakota; 200 at F. E. Warren AFB, Wyoming; and 50 in the 564th Strategic Missile Squadron (SMS), Malmstrom AFB, Montana (2:80-82).

Population

The population census consisted of all NS-20 failures that occurred at Grand Forks AFB during calendar year 1973. The population consisted of 160 failures distributed throughout calendar year 1973. See Figure 5. The population was divided into two major groupings.

Non-Stratified Population. The "non-stratified population" consisted of all 165 NS-20 failures, less five induced failures for a total of 160. An induced failure is caused by operation under conditions outside specification limits or by physical mishandling and was not considered appropriate to the objectives of this study.

Stratified Population. Two causes of failure were included in the stratified population: Pendulous Integrating Gyro Accelerometer (PIGA) failures and Digital Computer Unit (DCU) failures. To achieve any statistically

Month	Number Failures	PIGA	DCU	RTOK	GT-TI-B	MGSC	GCA	GSP	P92	Induced
Jan	19	4	5	3	3	3	1			
Feb	10	5		2	2		1			
Mar	16	7	4	4			1			
Apr	20	11	2	2	1	1		1	2	
May	12	7	1		2					2
Jun	17	10	3	1	1		1	1		
Jul	19	8	4	2	1	2		1		1
Aug	21	12	6					1		2
Sep	10	5	2	1	1	1				
Oct	3	1	1				1			
Nov	10	4	3	1	2					
Dec	8	4	1	3						
Total	165	78	32	19	13	7	5	4	2	5

PIGA . . . . Pendulous Integrating Gyro Accelerometer
DCU . . . . Digital Computer Unit
RTOK . . . . Retest OK
GT-TI-B . . . . . Gyro Compass
MGSC . . . . Missile Guidance Set Control
GSP . . . . Gyro Stabilized Platform
GCA . . . . Gyro Compass Assembly
P92 . . . . Amplifier Assembly
Induced . . . . . See "non-stratified population"

TOTAL FAILURES USED IN STUDY = 165 - (five induced failures)

= 160 Failures

Figure 5. Population of NS-20 Failure Data
Grand Forks AFB, Calendar Year 1973

meaningful results, a stratified grouping should contain at least thirty observations (17). PIGA failures and DCU failures consisted of seventy-eight and thirty-two observations respectively. Other causes of failure in the data consisted of less than twenty observations each, and therefore were not included in the stratified population. However, they were included in analysis of non-stratified population information described above (see Figure 5, page 27).

Data Source and Validity

NS-20 failure data was obtained from the Reliability and Quality Assurance Division, (MNDR), Space and Missile Systems Organization (SAMSO), Norton AFB, California. MNDR received the information on NS-20 failures from individual missile wings (19). The data was transmitted in the form of a "Not Reparable This Station" (NRTS) message. Each Minuteman wing transmitted a NRTS message every time a failed NS-20 was replaced (2:80-82). All failed NS-20s were repaired at the depot (15). Source data for the NRTS message was accumulated by automatic equipment in the missile complex. The automatic equipment recorded the cause of failure as well as the date and time of failure (21). The NRTS message contained the date and time of failure and cause of failure (19). Any questionable data in the message was resolved by a telephone call from MNDR to the wing concerned (19).

After the failed NS-20 was received and analyzed by the depot at Newark AFS, Ohio, all agencies concerned were notified of the depot's findings, that is, what the depot determined was the actual cause of failure (19). Cause of failure, time and date of failure information from both the wings and the depot was consolidated on an "MNDR file" and maintained at MNDR for reliability and quality control analysis (19). Since SAMSO used the MNDR data file to conduct Minuteman reliability and quality control studies (19), it was assumed that it accurately reflected the date and time of failure and cause of failure as determined by the depot. Figure 6 is an example of the data received from MNDR.

Environmental Data

Universe

Environmental data was collected at the Minuteman deployment area described previously. Common data included temperature, humidity, dew point, wind speed, wind direction, barometric pressure, cloud cover, visibility, rain and snow fall, and storm activity. Both ground level and upper atmosphere conditions were recorded. The observations were normally made hourly; however, when weather conditions were changing rapidly or were unusually turbulent, special observations were recorded.

MO/DAY	TIME	SILO	FFI	FAILURE VERIFICATION/ HARDWARE REPAIRED
3-01	0300	044	DCU	FFV/D37
3-04	1100	I35	DCU	FFV/D37
3-08	1513	043	PIG	FFV/PIGA
3-11	1617	B17	GCA	FFNV/RTOK
3-12	2042	G15	PIG	FFV/PIGA
3-16	0700	A05	PIG	FFNV/RTOK
3-16	0530	I40	PIG	FFV/PIGA
3-17	2144	D33	PIG	FFV/PIGA
3-21	1638	E43	PIG	FFV/PIGA
3-22	0137	G18	PIG	FFV/PIGA

Figure 6. Sample NS-20 Failure Data

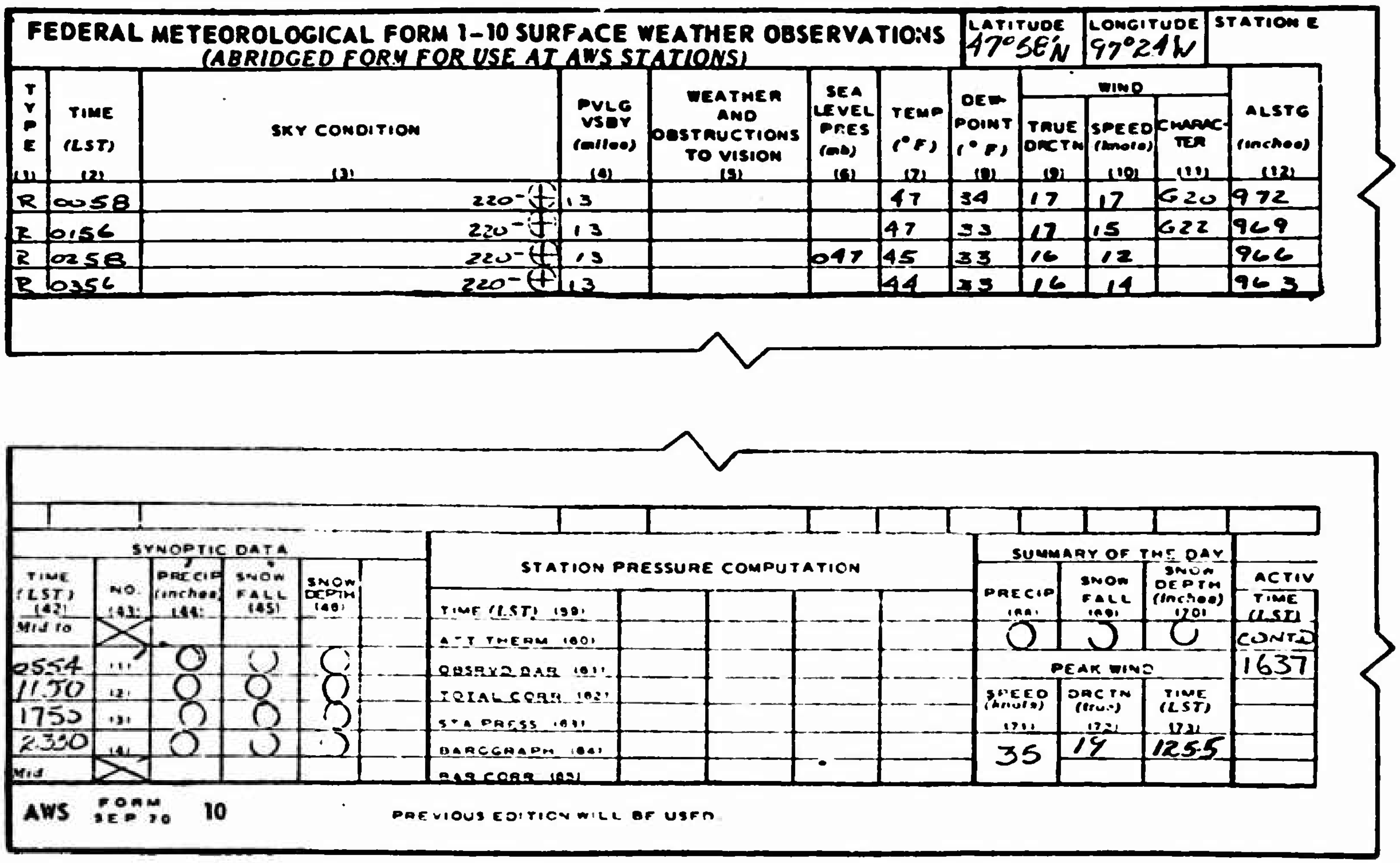
Population

The environmental data for this study was a population census of all the hourly observations of ground level temperature, barometric pressure, dew point, wind speed, and wind direction taken by Detachment 15, 3rd Weather Wing, Grand Forks AFB, North Dakota, from 30 December 1972 through 28 December 1973.

Data Source and Validity

The data was extracted from copies of original daily logs maintained by Detachment 15, 3rd Weather Wing (see Figure 7). The logs contained the following pertinent data: ground level temperature, barometric pressure, dew point, wind direction, and wind speed. According to Lt. Clark (9), Detachment 15, observations were taken hourly within plus or minus five minutes of the hour. Temperature readings were in degrees Fahrenheit and accurate to within plus or minus one degree. Barometric pressure was recorded in inches of mercury. Dew point was in degrees Fahrenheit and accurate to within plus or minus three degrees. Wind direction was rounded to the nearest ten degrees, i.e., a wind direction of 276 would be recorded as 280 degrees. Wind speed was in knots and represented a one minute average that included all peaks and lulls.

Since weather observations were not available for individual missile sites (11), it was assumed that the data collected at Grand Forks AFB was representative of



FEDERAL METEOROLOGICAL FORM 1-10 SURFACE WEATHER OBSERVATIONS
(ABRIDGED FORM FOR USE AT AWS STATIONS)

LATITUDE	LONGITUDE	STATION E
47°56'N	97°24'W	

TYPE (1)	TIME (LST) (2)	SKY CONDITION (3)	PVLG VSBY (miles) (4)	WEATHER AND OBSTRUCTIONS TO VISION (5)	SEA LEVEL PRES (mb) (6)	TEMP (°F) (7)	DEW-POINT (°F) (8)	WIND TRUE DRCTN (9)	WIND SPEED (knots) (10)	WIND CHARAC-TER (11)	ALSTG (inches) (12)
R	0058	220-⊕	13			47	34	17	17	G20	972
R	0156	220-⊕	13			47	33	17	15	G22	969
R	0258	220-⊕	13		047	45	33	16	12		966
R	0356	220-⊕	13			44	33	16	14		963

SYNOPTIC DATA

TIME (LST) (42)	NO. (43)	PRECIP (inches) (44)	SNOW FALL (45)	SNOW DEPTH (46)
Mid to	X			
0554	(1)	0	0	0
1150	(2)	0	0	0
1750	(3)	0	0	0
2330	(4)	0	0	0
Mid	X			

STATION PRESSURE COMPUTATION

TIME (LST) (59)				
ATT THERM (60)				
OBSRVD BAR (61)				
TOTAL CORR (62)				
STA PRESS (63)				
BAROGRAPH (64)				
BAR CORR (65)				

SUMMARY OF THE DAY

PRECIP (68)	SNOW FALL (69)	SNOW DEPTH (inches) (70)
0	0	0

PEAK WIND

SPEED (knots) (71)	DRCTN (true) (72)	TIME (LST) (73)
35	19	1255

ACTIV TIME (LST)
CONTD
1637

AWS FORM SEP 70 10 PREVIOUS EDITION WILL BE USED

Figure 7. Sample Weather Data

conditions throughout the missile complex. This assumption was based on two reasons: first, the opinion of Detachment 15 weather personnel was that weather conditions were fairly consistent throughout the missile complex at Grand Forks AFB (11); and second, the 150 missile sites were distributed from fifteen to one hundred miles north and south of Grand Forks AFB, and as a result differences tend to average out (11).

Data Processing--Step One

General

The data was prepared and entered into the computer in a two-step process. The first step was to enter the NS-20 failure data (date, time and cause of failure), and the environmental conditions existing at the time of failure (temperature, wind speed, wind direction, humidity, and barometric pressure). The second step was to enter the hourly temperature readings from 72 hours preceding time of failure up to the time of failure. Figure 8 is an example of an entry for the first step in the data input process. Each part of the entry will be described in the following paragraphs.

Processing of NS-20 Data

The raw data identified the date and time of each failure (to the nearest minute) and the cause of failure as

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Card Columns	1 - 7	9 - 16	19 - 22	25 - 28	31 - 33	36 - 37	40 - 44	47 - 48	51	54
Data	TBSF	Time of Failure	Time of Observ.	Temp.	Wind Dir- ection	Wind Speed	Pressure	Humidity	PIGA Fail.	DCU Fail.
Entry	24.00	250.25	250	10	340	5	30.21	55	1	0

The above entry is for an NS-20 that failed at 1015, 11 January 1973, due to a PIGA malfunction. The previous failure occurred 24.00 hours before or at 1015, 10 January 1973. The environmental data was recorded at 1000, 11 January 1973. Items 4 through 8 are the environmental conditions that existed at the time of failure.

Figure 8. Sample Data Entry

determined by the depot (19). The raw data was processed into usable information as follows:

Date and Time of Failure. See Item 2, Figure 8, page 34. The time was converted to decimal form. The date was converted into hours in the following manner:

$$[(\text{Julian Date} - 1) * 24] + \text{Time of Day}$$

Thus the date and time of each failure was converted into "Year Hours." Example: An NS-20 that failed at 1015, 11 January 1973, would have been converted as follows:

$$[(011 - 1) * 24] + 1025 = 250.25$$

Time Between Successive Failures. See Item 1, Figure 8, page 34. This data input was obtained by subtracting the time of the previous failure from the time of the current failure. This data was used in the multiple regression analysis as the dependent variable.

Cause of Failure. See Items 9 and 10, Figure 8, page 34. The only "causes of failure" that were explicitly coded were PIGA and DCU failures. This was accomplished by entering a "1" or an "0" in the appropriate column. For example, a PIGA failure would be represented by a "1" in column 51 and a "0" in column 54. A DCU failure would be represented by an "0" in column 51 and a "1" in column 54.

All other failures were coded by entering a "0" in both columns 51 and 54.

Environmental Data

The environmental data was processed as follows:

Date and Time of Observation. See Item 3, Figure 8, page 34. The time was rounded to the nearest hour. This meant a maximum of a five minute change. The resulting date/time group was then converted to year hours in the same manner as for NS-20 failure data.

Temperature. See Item 4, Figure 8, page 34. Temperature data was used as it appeared on the logs. When entered in the computer, the temperature readings required four columns. The first column indicated whether or not the reading was above or below zero, and the next three columns contained the degrees. Example: a temperature reading of 15 degrees below zero would appear as indicated in line a below, and a reading of 110 degrees above zero would appear as indicated in line b.

	Columns 19-22 (temperature)
a	-15
b	110

Wind Direction and Speed. See Items 5 and 6, Figure 8, page 34. Wind data was used as it appeared on

the logs. A wind reading of 280 degrees at 6 knots would appear as indicated below.

Columns 31-32 (direction)	Columns 36-37 (speed)
280	06

Barometric Pressure. See Item 7, Figure 8, page 34. Pressure readings were modified from the manner in which they appeared on the log. For example, a pressure reading of 30.21 inches appeared on the log as 021; a pressure reading of 29.68 inches appeared on the log as 968. The log readings were converted to the normal form of 30.27, 29.68, etc.

Humidity. See Item 8, Figure 8, page 34. To obtain the relative humidity readings it was necessary to convert the dew point readings on the logs into humidity readings. The conversion was accomplished by the use of a "Relative Humidity (percent) From Temperature and Temperature-Dewpoint Depression" conversion chart (see Figure 9). To obtain this conversion from the chart it required the following:

1. Convert the temperature and time of failure and the dew point temperature to degrees Centigrade that equate to degrees in Fahrenheit.

2. Obtain the difference between the temperature at the time of failure and the dew point temperature (degree Centigrade).

TEMPERATURE*

D* DEWPOINT DEPRESSION

	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40
[illegible]	[illegible]	95	94	94	94	94	94	93	93	93	92	92	92	91	91	91	90
[illegible]	[illegible]	89	89	89	88	88	87	87	86	86	85	85	84	83	83	82	81
[illegible]	85	85	84	83	83	82	82	81	80	79	79	78	77	76	75	74	73
[illegible]	81	80	79	78	78	77	76	75	74	73	73	71	[illegible]	69	68	67	66
[illegible]	[illegible]	75	75	74	73	72	71	70	69	68	67	66	64	63	62	60	59
[illegible]	72	71	70	69	68	67	66	65	64	[illegible]	61	60	59	57	56	54	53
[illegible]	[illegible]	67	66	65	64	63	62	61	59	[illegible]	57	[illegible]	[illegible]	52	51	49	47
[illegible]	64	63	62	61	60	59	57	56	[illegible]	53	52	50	49	47	46	44	42
[illegible]	61	60	59	57	56	55	54	52	51	49	48	46	45	43	41	39	38
[illegible]	58	56	55	54	53	51	50	48	47	45	44	42	41	39	37	35	34
[illegible]	54	53	52	50	49	48	[illegible]	45	43	42	40	39	37	35	33	32	[illegible]
[illegible]	51	50	49	47	46	45	43	41	40	38	37	35	34	32	30	28	[illegible]
[illegible]	48	47	46	44	43	42	40	38	37	35	34	32	30	29	27	25	21
[illegible]	46	44	43	41	40	39	[illegible]	36	34	32	31	[illegible]	28	26	24	23	[illegible]
[illegible]	43	42	40	39	37	36	34	33	31	30	28	27	25	[illegible]	22	20	16
16	40	39	38	36	35	33	32	30	29	27	26	24	23	21	20	16	
17	38	37	35	34	32	31	29	28	27	25	23	22	21	19	18	14	
18	36	34	33	32	30	29	27	26	24	23	21	20	19	17	16	12	
19	34	32	31	30	28	27	25	24	22	21	20	18	17	15	14	11	
20	32	30	29	28	26	25	23	22	21	19	18	16	15	14	12	09	
21	30	28	27	26	24	23	22	20	19	17	16	15	14	12	09		
22	28	27	25	24	23	21	20	19	17	16	15	13	12	11	08		
23	26	25	24	22	21	19	18	17	16	15	15	12	11	10	07		
24	25	23	22	21	19	18	17	16	14	13	12	11	10	09	06		
25	23	22	21	19	18	17	16	14	13	12	11	10	09	08	06		
26	22	20	19	18	17	16	15	13	12	11	10	09	08	05			
27	20	19	18	17	16	14	14	12	11	10	09	08	07	05			
28	19	17	17	15	14	13	12	11	10	09	08	07	06	04			
29	18	17	[illegible]	[illegible]	13	12	11	10	09	08	07	06	[illegible]	04			
30	17	[illegible]	[illegible]	[illegible]	12	12	10	09	08	07	[illegible]	06	08	03			

*Both scales are in degrees centigrade

Figure 9. Dewpoint/Humidity Conversion Chart (18:424)

3. Using the temperature at the time of failure in Centigrade (across the top) and the difference from Step 2 (left side), enter Figure 9 (page 38) and obtain the humidity. A dew point reading of 25 degrees Fahrenheit would appear as indicated below.

Columns 47-48 (humidity)
(86 percent)

Data Processing--Step Two

Follow-on Input of Temperature Data

The second step of the data input process was to enter the hourly temperature readings for the 72 hours immediately preceding the time of each failure. Figure 10 is an example of the entries for this step in the data input process.

	(1)	(2)	(3)
Card Columns	1 - 3	6 - 7	10 - 13
Data	Julian Date	Time	Temp.
Entry	025	10	15

Figure 10. Sample Temperature Input

Date/Time of Temperature Readings

See Items 1 and 2, Figure 10. The data in columns 1 through 7 was processed and entered in exactly the same manner as described in the paragraph titled "Date and Time of Observation."

Temperature Data

See Item 3, Figure 10. The data in columns 10 through 13 was processed and entered in exactly the same

manner as described in the paragraph titled "Temperature."

Environmental Variables

After the environmental data was processed and entered into the computer, it was used to compute the following variables for each failure.

- T_1 - Temperature at time of failure.
- $T2_n$ - Average temperature preceding failure (see below).
- $T3_n$ - Average rate-of-temperature change preceding failure (see below).
- WS - Wind speed at time of failure.
- WD - Wind direction at time of failure.
- H - Relative humidity at time of failure.
- P - Barometric pressure at time of failure.

$T2_n$--Average Temperature Prior to Failure. Average temperature prior to failure was computed in six-hour increments from the time of failure, up to 72 hours preceding the time of failure, where n = 6, 12, 18, 24...72. Smaller time intervals were not selected due to the large number of calculations involved. The computations resulted in twelve groups of data representing the average temperature prior to failure in six-hour increments ranging from six to 72 hours preceding each failure.

$T3_n$--Average Rate-of-Temperature Change Prior to Failure. The average rate-of-temperature change prior to failure was computed in one-hour increments from one hour up to twelve hours preceding the time of failure where

$n = 1 - 12$. The computations resulted in twelve groups of data representing the average rate-of-temperature change from one to twelve hours preceding each failure. The average rate-of-temperature change was computed by dividing the absolute total change in temperature for a period by the number of hours in the period. Example: Assume a failure occurred at 1000 and the following temperatures were observed during the preceding four hours.

Time	Temperature	Change (absolute)
1000	+015	- (time of failure)
0900	+023	7
0800	+030	7
0700	+025	5
0600	+020	5
		24 ÷ 4 = 6 degrees per hour

Therefore, for this failure $T3_4 = 6$.

Dependent Variables

Three dependent variables were computed for use in the multiple regression equations. The computation and classification of these variables is described below.

TBSF (All Causes)--Group 1. This variable represents TBSF for all NS-20 failures in the total or non-stratified population. The procedure for computing TBSF was to round the time of failure to the nearest tenth of an hour; then convert the rounded time to "year-hours" as described in the section titled "Date and Time of Failure;" and finally to compute TBSF as described in the

section titled "Time Between Successive Failures." TBSF meets the criteria for multiple regression analysis (interval level data), since it is a measure of time. Time satisfies the criteria of ratio level data since it can be conceptually measured as having an absolute zero as well as equal units (16:179). Therefore, TBSF of all NS-20 failures is at least interval level data. However, the criteria have not been met for F-tests since by definition the data is a population and not a representative sample of a process population.

TBSF (Due to DCU Failures)--Group 2. This variable represents one stratum of the stratified population; i.e., the TBSF for all NS-20 failures due to DCU malfunctions. Since its computation was the same as TBSF (all causes), it also meets the data level criteria for multiple regression analysis.

TBSF (Due to PIGA Failures)--Group 3. This variable represents the other stratum of the stratified population; i.e., the TBSF for all NS-20 failures due to PIGA malfunctions. Since its computation was the same as TBSF (all causes), it also meets the data level criteria for multiple regression analysis.

Independent Variables

Seven independent variables were computed for use in the multiple regression equations. The computation

and classification of these variables is described below.

Temperature at Time of Failure (T1). The time of each temperature reading was rounded to the nearest hour; then the time was converted to "year-hours" as described in the section titled "Date and Time of Failure." The temperature at time of failure was then determined by selecting the year-hour of a temperature observation that came closest to the year-hour of an individual failure. Temperature at Time of Failure meets the criteria or interval level or better data for multiple regression analysis since any data that allows a determination of differences in magnitude is classified as interval data (16:179).

Wind Speed at Time of Failure (WS). The computation and data level classification of this variable was the same as for "Temperature at Time of Failure."

Wind Direction at Time of Failure (WD). The computation and data level classification of this variable was the same as for "Temperature at Time of Failure."

Humidity at Time of Failure (H). The computation and data level classification of this variable was the same as for "Temperature at Time of Failure."

Barometric Pressure at Time of Failure (BP). The computation and data level classification of this variable was the same as for "Temperature at Time of Failure."

Average Temperature Prior to Failure ($T2_n$). This variable was computed as described in the section titled "$T2_n$--Average Temperature Prior to Failure." The $T2_n$ variable was considered as interval level data since it allows a determination of differences in magnitude (16:179).

Average Rate-of-Temperature Change Prior to Failure ($T3_n$). This variable was computed as described in the section titled "$T3_n$--Average Rate-of-Temperature Change Prior to Failure." The $T3_n$ variable was considered as interval level data since it allows a determination of differences in magnitude (16:179).

Summarization of Data

Introduction

The data was arrayed in two types of files, intermediate and final. The intermediate files consisted of raw data with minimum changes. The final files were in a format that was readily used by the BMD02R Multiple Regression Program. The BMD02R program is described in Chapter IV, "Data Analysis." Files were arrayed and entered into the computer as follows.

Intermediate Files

These files were used as vehicles to initially enter and process the raw data. After being checked and verified, the intermediate files served as a data source for the creation of the final files.

Intermediate File CLSC1. This file contained the raw NS-20 failure data and the environmental conditions existing at the time of failure. The only changes to the data were: converting the dates to Julian days, the hours to decimal form, and rounding the time of the weather observation to the nearest hour. The conversions were accomplished manually and the data was input from worksheets created from basic documents. The file was constructed as indicated in Figure 11.

Julian Date	TOF*	TOWO**	Temp	Dew Point	Wind Dir	Wind Speed	Press	PIGA Fail.	DCU Fail.
002,	8.9,	9,	014,	007,	160,	15,	29.80,	0,	0

*TOF . . . . Time of Failure
**TOWO . . . Time of Weather Observation

Figure 11. File CLSC1

Intermediate File CLSC2. This file was a further refinement of file CLSC1. It contained the same data as CLSC1 with the addition of time between Successive Failures; and dew point converted to relative humidity. The file

was created by computer program MOD1 listed in Appendix D. The file appeared as previously indicated in Figure 8 on page 34.

Intermediate File TEMP. This file contained all the required temperature data for each NS-20 failure, that is, it contained the temperature at time of failure, and the hourly temperature readings for a 72 hour period preceding each failure. The only changes to the data were: converting dates to Julian days and rounding the time to the nearest hour. The file appeared as indicated in Figure 12.

Julian Date	TOWO*	Temp
002,	9,	014

*Time of Weather Observation.

Figure 12. File TEMP

Final Files

The final files contained all of the variables in a compatible format that were needed to conduct the multiple regression analysis on the BMD02R Program. Each of the final files is briefly described below. All of the files except File T1 were created by computer program MOD2 listed in Appendix D. File T1 was created by program MOD1.

File T1--All NS-20 Failures. This file contained all the NS-20 failures. The failures were listed in chronological sequence. The entry for each file contained: TBSF, temperature, wind speed, wind direction, humidity, and pressure at time of failure; and the cause of failure (PIGA, DCU or other).

File T1D--NS-20 Failures Due to DCU Malfunctions. This file was identical to File T1, except that it contained only DCU-caused failures.

File T1P--NS-20 Failures Due to PIGA Malfunctions. This file was identical to File T1, except that it contained only PIGA-caused failures.

Tile T2A and T2B--Average Temperature Prior to All NS-20 Failures. These files contained the same data as File T1 with the exception of the temperature at the time of failure. In addition, they contained the average temperature computations for the twelve six-hour periods preceding each failure. File T2A contained the data for periods one through six; that is, the average temperature existing during the 6, 12, 18, 24, 30, and 36 hour time periods preceding each NS-20 failure. File T2B contained the average temperature data for periods seven through twelve, i.e., for the six-hour increments going from 42 to 72 hours prior to the time of failure.

File T2DA and T2DB--Average Temperature Prior to DCU-Caused Failures. These files were identical to File T2A and T2B, except that they contained only those NS-20 failures caused by DCU malfunctions.

Files T2PA and T2PB--Average Temperature Prior to PIGA-Caused Failures. These files were identical to files T2A and T2B, except that they contained only those NS-20 failures caused by PIGA malfunctions.

Files T3A and T3B--Average Rate-of-Temperature Change Prior to All NS-20 Failures. These files contained the same data as File T1 with the exception of the temperature at time of failure. In addition, they contained the average rate-of-temperature change computations for the twelve-hour periods preceding each failure. File T3A contained the data for hours one through six preceding each failure; that is, the average rate-of-temperature change occurring during hours one through six. File T3B contained the data for hours seven through twelve.

Files T3DA and T3DB--Average Rate-of-Temperature Change Prior to DCU-Caused Failures. These files were identical to Files T3A and T3B, except that they contained only those NS-20 failures caused by DCU malfunctions.

Files T3PA and T3PB--Average Rate-of-Temperature Change Prior to PIGA-Caused Failures. These files were

identical to Files T3A and T3B, except that they contained only those NS-20 failures caused by PIGA malfunctions.

Assumptions

a. It was assumed the weather data collected at Grand Forks AFB was representative of conditions throughout the missile complex.

b. The time period considered, 1 January through 31 December 1973, was of sufficient length of yield sufficient data to meet the objectives of this study.

c. The data collected yielded valid information.

Limitations

The conclusions derived from the research apply only to the population census of NS-20 failures at Grand Forks AFB for Calendar Year 1973.

Summary

At this point the data was ready for use in the BMD02R Multiple Linear Regression Program. Chapter IV consists of an analysis of the data that was produced by the BMD02R program.

CHAPTER IV

DATA ANALYSIS AND TESTING OF HYPOTHESIS

Introduction

A total of 159 multiple regression equations were computed. Seventy-five equations were originally planned, however, additional equations were necessary to allow an investigation of a relationship between the average rate-of-temperature change variable and the stratified population. Each one of the regression equations was an attempt to find a relationship between TBSF and external environmental conditions. The following paragraphs present generalized descriptions of the equations.

Analysis of NS-20 Non-Stratified Population

The non-stratified population included all NS-20 failures that occurred at Grand Forks during 1973. Twenty-five equations were computed in an attempt to find a relationship between the non-stratified population and environmental conditions (see Figure 13). One equation (see Equation 1 below) consisted of a prediction of TBSF in terms of environmental conditions that existed at the time of failure, i.e., temperature, wind speed, wind direction, humidity, and pressure.

DEPENDENT VARIABLES (TBSF)	INDEPENDENT VARIABLES (ENVIRONMENTAL CONDITIONS)			TOTAL R^2 EQUATIONS
	GROUP A*	GROUP B**	GROUP C***	
GROUP ONE FAILURES (Non-Strat Population)	TEMP, WS, WD, H, P (T1)	TEMP, WS, WD, H, P ($T2_n$) n=1,12...72	TEMP, WS, WD, H, P ($T3_n$) n=1,2...12	25
	#Equations=1 Appendix A-1	#Equations=12 Appendix A-2 Eqs. 1-12	#Equations=12 Appendix A-3, Eqs. 1-12	
GROUP TWO FAILURES (Stratified Population) DCU Stratum	TEMP, WS, WD, H, P (T1)	TEMP, WS, WD, H, P ($T2_n$) n=6,12...72	TEMP, WS, WD, H, P ($T3_n$) n=1,2...72	85
	#Equations=1 Appendix B-1	#Equations=12 Appendix B-2, Eqs. 1-12	#Equations=72 Appendix B-3, Eqs. 1-72	
GROUP THREE FAILURES (Stratified Population) PIGA Stratum	TEMP, WS, WD, H, P (T1)	TEMP, WS, WD, H, P ($T2_n$) n=6,12...72	TEMP, WS, WD, H, P ($T3_n$) n=1,2...36	49
	#Equations=1 Appendix C-1	#Equations=12 Appendix C-2, Eqs. 1-12	#Equations=36 Appendix C-3, Eqs. 1-36	
TOTAL R^2 EQUATIONS	3	36	120	159

*These regression equations attempt to predict TBSF in terms of environmental conditions existing at the time of failure, i.e., temperature, wind direction, wind speed, humidity and pressure.

**These regression equations attempt to predict TBSF in terms of average temperature conditions existing prior to the time of failure, in addition to conditions existing at the time of failure, i.e., wind direction, wind speed, humidity and pressure. Twelve time periods were selected: 6, 12, 18, 24, 30, 36, 42, 48, 54, 60, 66 and 72 hours preceding time to failure.

***These regression equations attempt to predict TBSF in terms of the average rate-of-temperature change conditions existing prior to the time of failure, in addition to conditions existing at the time of failure, i.e., wind direction, wind speed, humidity and pressure. Up to 72 time periods were selected: 1, 2, 3...72 hours prior to time of failure.

Figure 13. Summary of Multiple Regression Equations

Twelve equations (see Equation 2 below) consisted of predictions of TBSF in terms of "average temperature conditions prior to failure" and the environmental conditions existing at time of failure. The last twelve equations (see Equation 3 below) consisted of predictions of TBSF in terms of "average rate-of-temperature change" conditions prior to failure and the environmental conditions existing at the time of failure.

Variables

Y_m = TBSF of NS-20 Non-Stratified Population.

X_1 = Wind Speed at the time of failure (TOF).

X_2 = Wind Direction at TOF.

X_3 = Barometric Pressure at TOF.

X_4 = Humidity at TOF.

X_5 = Temperature at TOF.

X_{6n} = Average Temperature Conditions Existing Prior to Failure (computed in 12 six-hour periods). n = 6, 12, 18...72.

X_{7n} = Average Rate-of-Temperature change Conditions Existing Prior to Failure (computed in twelve one-hour periods). n = 1, 2, 3...12.

b_0 = Constant.

$b_1 \ldots b_n$ = Coefficient of the Independent Variables $X_1 \ldots X_n$.

Equations

(1) $Y_m = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5$

(2) $Y_m = b_0 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_{6n}X_{6n}$

(3) $Y_m = b_0 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_{7n}X_{7n}$

Analysis of NS-20 Stratified Population

The stratified population consisted of thirty-one DCU-caused failures and seventy-seven PIGA-caused failures. Each cause of failure (DCU and PIGA) was grouped separately, and then each group was analyzed in exactly the same manner as for the non-stratified population. A total of 134 equations were computed in an attempt to find a relationship between the TBSF of the groups of the stratified population and the environmental conditions. During analysis of the DCU group, Y_m in equations 1, 2, and 3 above was set equal to the TBSF due to DCU malfunctions. During analysis of the PIGA group, Y_m was set equal to the TBSF due to PIGA malfunctions.

Computation of Equations

The actual computation of the multiple regression equations was accomplished by using the BMD02R Multiple Linear Regression Program. This computer program was developed by the Health Sciences Computing Facility of the University of California at Los Angeles. The BMD02R program computes a sequence of multiple linear regression equations in a stepwise manner. At each step one variable is added to the regression equation. The variable

added is the one which makes the greatest reduction in the error of the sum of squares (26:232); that is, the variable that will increase the R^2 value (coefficient of determination) more than any of the other available independent variables; i.e., environmental factors. R^2 is the proportion of the total variation in the dependent variable explained by the regression equation (29:492). See section titled "Criteria Test," Chapter II, for a detailed explanation of R^2.

BMD02R Output

A summarization of the BMD02R program output is presented in Figure 14. A brief explanation of the meaning of each item in Figure 14 follows:

(1) DF means degrees of freedom. The top figure represents upper degrees of freedom; the bottom figure represents lower degrees of freedom for the F ratio (2) discussed below. For the F to remove values (6) the upper degree of freedom is always one and the lower degree of freedom is the same as for the F ratio.

(2) F Ratio represents the statistical significance of the ability of the equation to predict the value of the dependent variable when all five independent variables are considered.

(3) SS/PS are symbols entered by the authors to indicate whether the F-Ratio is statistically significant (SS) at the .05 level or practically significant (PS) in

```
1 DF        2 F RATIO   (PS,SS) 3                    10  10
   5          2.299
  71

                         VARIABLES IN EQUATION    5          6
VARIABLE          4   COEFFICIENT   STD. ERROR   F TO REMOVE

(CONSTANT           1815.13310 )
   WD   2              0.04905       0.11254        0.1900 (3)
   WS   3             -0.73598       2.51391        0.0857 (3)
 PRES   4            -54.00536      57.61564        0.8786 (3)
  HUM   5             -0.23110       0.84927        0.0740 (3)
 T310   9            -44.80348      15.40929        8.4539 (3)
                 7
      VARIABLE                8        MULTIPLE         9
ENTERED   REMOVED                 R              RSQ

T310    9                         0.3544         0.1256
PRES    4                         0.3680         0.1354
  WD    2                         0.3711         0.1377
  WS    3                         0.3721         0.1384
 HUM    5                         0.3733         0.1393
```

Figure 14. Sample BMD02R Output

accordance with the criteria rule established in the section titled "Decision Rule." The absence of either or both SS and PS indicates that the equation is not statistically significant or of practical significance. The F-ratio and statistical test was included for the convenience of those individuals who wish to consider the data as a representative sample of a process population in which case the use of a statistical test is appropriate.

(4) Variables in Equation. Displays variables in the regression equation. The general form of the equation is:

$$Y_m = b_0 + b_1X_1 + b_2X_2 \; . \; . \; . \; b_nX_n$$

Y_m = TBSF

b_0 = Constant

$b_1 - b_n$ = Coefficients for independent variables

$X_1 - X_n$ = Independent variables of wind speed, wind direction, humidity, pressure, and temperature condition

Example: In Figure 14, the equation would appear as follows:

$$Y_m = 1815.3310 - .04905X_1 - .73598X_2 - 54.00536X_3 - .23110X_4 - 44.80348X_5$$

where X_1 = wind direction; X_2 = wind speed; X_3 = pressure; X_4 = humidity; and X_5 = temperature condition.

The variables representing wind speed, wind direction, humidity, and pressure are self-explanatory; however, the temperature variables are somewhat complex. Therefore, the temperature variables are defined as follows: T1 represents temperature existing at the time of failure. T2n represents the average temperature existing for a specific time prior to failure, i.e., T26 represents the average temperature that existed during the six-hour period immediately preceding failure, etc. n = 6, 12, 18, ... 72. T3n represents the average rate-of-temperature change that existed for a specific time prior to failure; i.e., T39 represents the average rate-of-temperature change that existed for nine hours preceding failure; T310 represents temperature change for ten hours preceding failure, etc. n = 1, 2, 3 ... 72.

(5) Standard Error. A measure of the variation of the sample around the expected value of that sample, i.e., standard deviation.

(6) F to Remove represents the statistical significance of the relationship between that independent variable and the dependent variable with all other variables being held constant.

(7) Variable Entered/Removed represents variables entered in the regression equation. In this study no variables were removed.

(8) R is the correlation coefficient of the equation after each independent variable is added to the equation.

(9) RSQ is the coefficient of determination or R^2 of the equation after each independent variable is added to the equation.

(10) An equation number entered by the researchers to assist the reader in identifying specific equations.

Analysis of the Output

The total output of the BMD02R consisted of 159 multiple regression equations outlined in Figure 14 on page 55. The equations were grouped for analysis as indicated:

1. Group one contains twenty-five equations produced as the result of regressing TBSF (Group 1, non-stratified population) against environmental Groups A, B, and C. See Figure 13, page 51.

2. Group two contains eighty-five equations as the result of regressing TBSF (Group 2, stratified population) DCU strata, against environmental groups A, B, and C. See Figure 13, page 51.

3. Group three contains forty-nine equations produced as the result of regressing TBSF (Group 3, stratified population) PIGA strata, against environmental Groups A, B, and C. See Figure 13, page 51.

Due to the large number of equations involved, the summary results are listed in the following appendices.

Appendix A - Failure Group One equations versus Environmental Groups A, B, and C.

Appendix B - Failure Group Two equations versus Environmental Groups A, B, and C.

Appendix C - Failure Group Three Equations versus Environmental Groups A, B, and C.

Throughout the analysis that follows, the term "inverse relationship" is used several times. The term is used to describe the relationship between the dependent variable and one or more independent variables. The term is defined below for the various situations under which the term might be used. An inverse relationship between the TBSF and a particular environmental condition would mean that as the condition (temperature, humidity, barometric pressure, wind speed, average temperature or average rate-of-temperature change) INCREASED/DECREASED, TBSF would do the opposite; i.e., DECREASE/INCREASE. Some of the regression equations indicated that an inverse relationship existed between wind direction and TBSF. This occurred since wind direction was measured from zero to 360 degrees, and for each failure mode a mean wind direction was computed. During the computation of a regression equation, the BMD02R program may have noted that as wind direction varied from, for example, a mean of 180 degrees toward 200 degrees, i.e., INCREASED, the TBSF DECREASED. Therefore, it would indicate that an inverse

relationship existed. A direct relationship means the dependent and independent variables both move in the same direction.

Analysis of Group One Equations

This group is analyzed as indicated in Figure 15. The first equation regresses Group One failures against environmental Group A. The next twelve equations regress Group One failures against environmental Group B. The last twelve equations regress Group One failures against environmental Group C.

Failure Group One vs. Environmental Group A

See Appendix A-1. This regression indicated an inverse relationship between temperature/pressure at time of failure and TBSF. That is, as temperature/pressure decreased, the TBSF increased. The other variables (wind speed, wind direction, and humidity) were indicated as having a direct relationship with TBSF. Temperature contributed the most to R^2 (.0085), followed by wind speed (.0029), wind direction (.0020), humidity (.0002), and pressure (.0001). The total R^2 value was a rather low .0136, which may be interpreted as meaning that the environmental conditions at time of failure explained 1.36 percent of the variance in the TBSF.

DEPENDENT VARIABLES (TBSF)	INDEPENDENT VARIABLES (ENVIRONMENTAL CONDITIONS)			TOTAL EQS.
	GROUP A	GROUP B	GROUP C	
GROUP ONE FAILURES (Non-strat Population)	TEMP, WS, WD, H, P (T1)	TEMP, WS, WD, H, P $T(2_n)$ n=6,12...72	TEMP, WS, WD, H, P $(T3_n)$ n=1,2...12	
	#Equations = 1 See Appendix A-1.	#Equations = 12. See Appendix A-2, Eqs. 1-12.	#Equations = 12. See Appendix A-3, Eqs. 1-12.	25

Figure 15. Group One Equations vs. Environmental Groups A, B, and C

Failure Group One vs. Environmental Group B

See Appendix A-2. All twelve regression equations in this grouping indicated an inverse relationship between: (1) average temperature conditions existing prior to failure and TBSF; and (2) barometric pressure existing at time of failure and TBSF. With the exception of the first equation, humidity was indicated as having a direct relationship with TBSF. Wind speed and wind direction were indicated as having a direct relationship in all equations. The major contributors to R^2 were the average temperature and barometric pressure variables. The combined contribution of these two variables ranged from 68 to 80 percent of the total R^2 (.0117-.0155) with an average contribution of 74 percent.

The values of the twelve R^2s are plotted in Figure 16. The range of R^2 was from .0117 in the twelfth equation to a high of .0155 in the second equation. This may be interpreted as meaning that environmental conditions at the time of failure plus average temperature conditions existing prior to failure explain from 1.17 to 1.55 percent of the variance in TBSF.

Failure Group One vs. Environmental Group C

See Appendix A-3. The inverse relationships indicated in these equations were between TBSF and (1) pressure for all equations, (2) the rate-of-temperature change variable for equations two through twelve, and (3) humidity

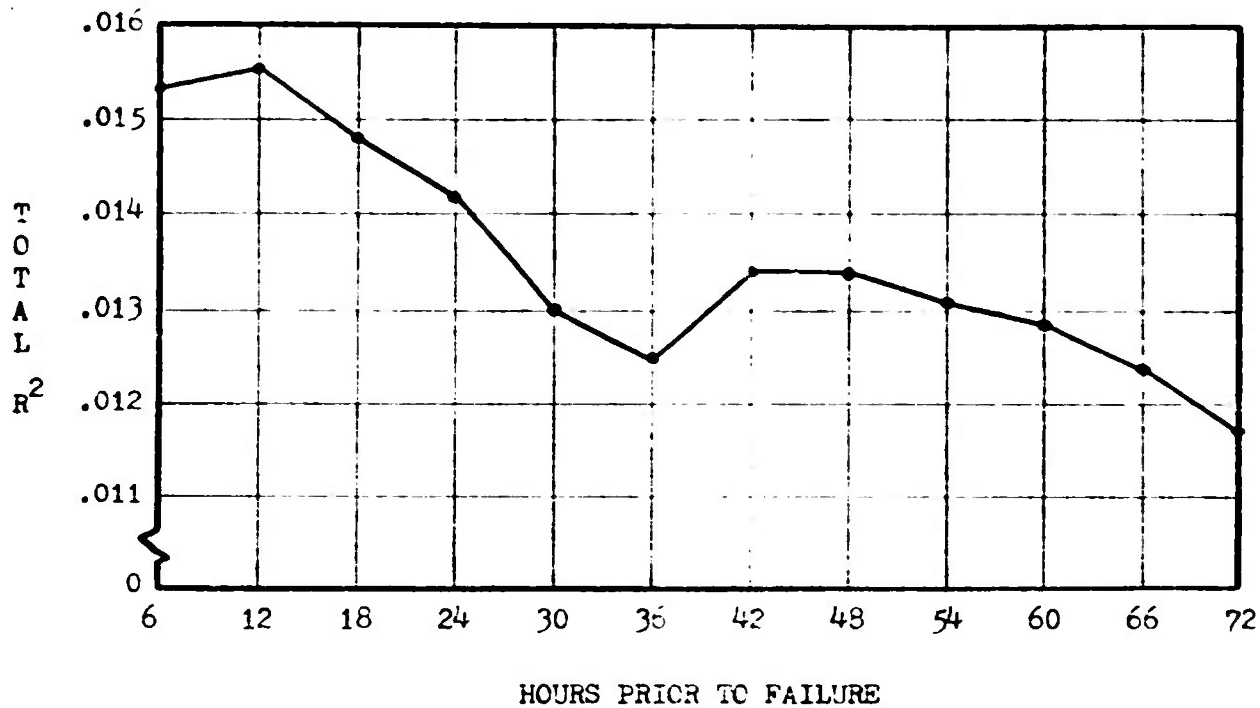


Figure 16. Failure Group One vs. Environmental Group B

for equations three through twelve, and (4) wind speed for equations nine through twelve. With the exception of equation one, the average rate-of-temperature change variable was the major contributor to R^2; the contribution for equations two through twelve ranged from 58 to 85 percent, with an average contribution of 74 percent. The value of R^2 for equations one through twelve is plotted on the graph in Figure 17. The value of R^2 ranged from .0065 in equation one, to a high of .0520 in equation twelve. This may be interpreted as meaning that from .65 to 5.2 percent of the variance in TBSF is explained by environmental conditions at time of failure, plus the average rate-of-temperature change variable.

Summary of Group One Analysis

The equations in this group indicated an inverse relationship between TBSF for all NS-20 failures and (1) the temperature variables, and (2) pressure. In all cases the temperature variable was the major contributor to R^2. The highest R^2 value (.0520) obtained in this group was in equation twelve where group one failures were regressed against environmental Group C.

Analysis of Group Two Equations

This group is analyzed as indicated in Figure 18. The first equation regresses the group two failures against environmental Group A. The next twelve equations

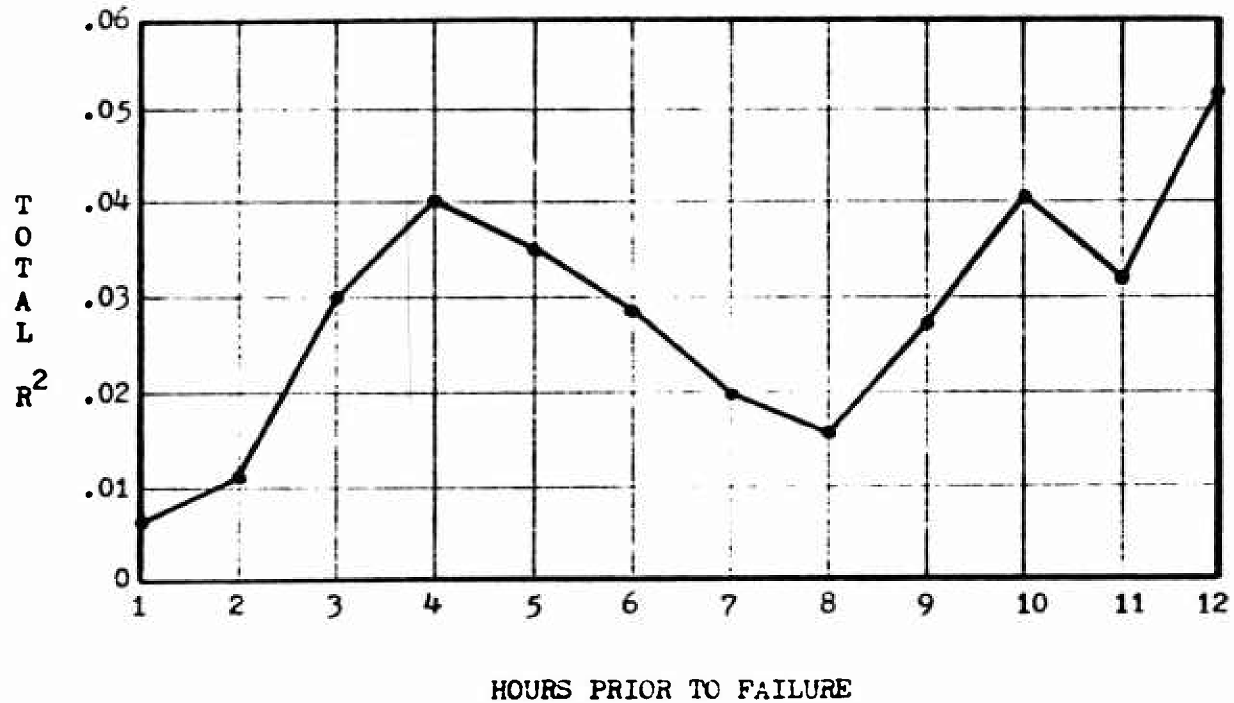


Figure 17. Failure Group One vs. Environmental Group C

DEPENDENT VARIABLES (TBSF)	INDEPENDENT VARIABLES (ENVIRONMENTAL CONDITIONS)			TOTAL EQS.
	GROUP A	GROUP B	GROUP C	
GROUP TWO FAILURES (Stratified Population) DCU Stratum	TEMP, WS, WD, H, P (T1)	TEMP, WS, WD, H, P ($T2_n$) n=6,12...72	TEMP, WS, WD, H, P ($T3_n$) n=1,2...72	85
	#Equations = 1 See Appendix B-1	#Equations = 12 See Appendix B-2, Eqs. 1-12.	#Equations = 72 See Appendix B-3, Eqs. 1-72	

Figure 18. Group Two Equations vs. Environmental Groups A, B, and C

regress group two failures against environmental Group B. The last 72 equations regress Group two failures against environmental Group C.

Failure Group Two vs. Environmental Group A

See Appendix B-1. This regression indicated an inverse relationship between temperature at the time of failure and TBSF of DCU malfunctions. All other variables (wind speed, wind direction, and humidity) were indicated as having a direct relationship with the TBSF of DCUs. The major contributors to R^2 (.2338) were wind speed (.1063) and pressure (.0993); wind direction, humidity and temperature contributed .0248, .0033 and .0001 respectively. The total R^2 value was .2338, which may be interpreted as meaning that the environmental conditions at the time of failure explained 23.38 percent of the variance in TBSF of DCUs.

Failure Group Two vs. Environmental Group B

See Appendix B-2. There were no inverse relationships in this group of equations; all variables indicated a direct relationship with TBSF of DCUs. In each equation, wind speed and barometric pressure were major contributors to R^2. Wind speed and pressure combined accounted for 83 to 84 percent of the total R^2 (.2155-.2174 in every equation. The contributions to R^2 for wind speed (.1063), barometric pressure (.0737), wind direction

(.0317) and humidity (.0035) remained constant throughout all twelve equations. The variance in the R^2 values plotted in Figure 19 was due to the variation in the contribution of the average temperature variable. In all twelve equations, the average temperature variable contributed the least to the R^2 value. The R^2 value ranged from .2155 in equation 1, 2, and 4, to a high of .2174 in equation 5. This may be interpreted as meaning that environmental conditions at time of failure plus average temperature conditions prior to failure explained from 21.55 to 21.74 percent of the variance in TBSF of DCUs.

Failure Group Two vs. Environmental Group C

See Appendix B-3. The original plan for this grouping was to compute twelve equations. However, equations ten, eleven, and twelve seemed to indicate that an increasingly significant relationship was developing between the average rate-of-temperature change variable and TBSF of DCUs. Therefore, an additional twelve equations were computed to investigate the effect of the rate-of-change in temperature on the TBSF up to twenty-four hours preceding the time of failure. However, again the last equations 21, 22, 23, and 24 indicated that a relationship was developing between the average rate-of-temperature change variable and TBSF. Therefore, another twelve equations were computed, and again the last equations 33, 34, 35, and 36 indicated that a relationship was

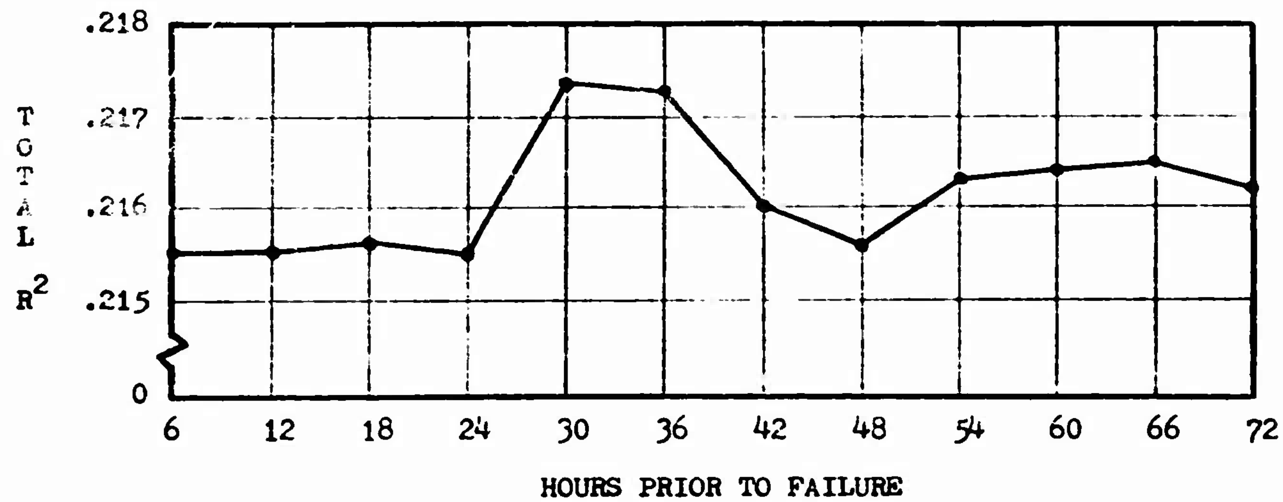


Figure 19. Failure Group Two vs. Environmental Group B

developing. Therefore, the relationship between the rate-of-temperature change and TBSF was computed at one hour intervals for 72 hours prior to the time of failure.

At the 37 hour point the R^2 value fell sharply and remained at a relatively low level for equations 37 through 72. See Figure 20. The cycling phenomena remains a mystery. Since the peaks of the cycles fell at nearly twelve hour intervals and were fairly sharply defined, graphs were drawn to see if DCU failures were related to time of day or time of year. No obvious relationship was noted through an inspection of these graphs depicted in Figures 21 and 22. A regression analysis was not accomplished to formally determine if a relationship existed between DCU failures and the time of day or the time of year because the inspection of Figures 21 and 22 indicates no obvious relationship exists.

The equations indicated that an inverse relationship existed between the rate-of-temperature change variable and the TBSF of DCUs. All equations, except 26, 58, 59, and 60, indicated that an inverse relationship existed between humidity and TBSF. The equations indicated the other variables (pressure, wind speed, and wind direction) had a direct relationship with TBSF. The major contributor to R^2 depended upon the time period involved. Figure 23 indicates what percentage of R^2 was attributable to the rate-of-temperature change variable. The time

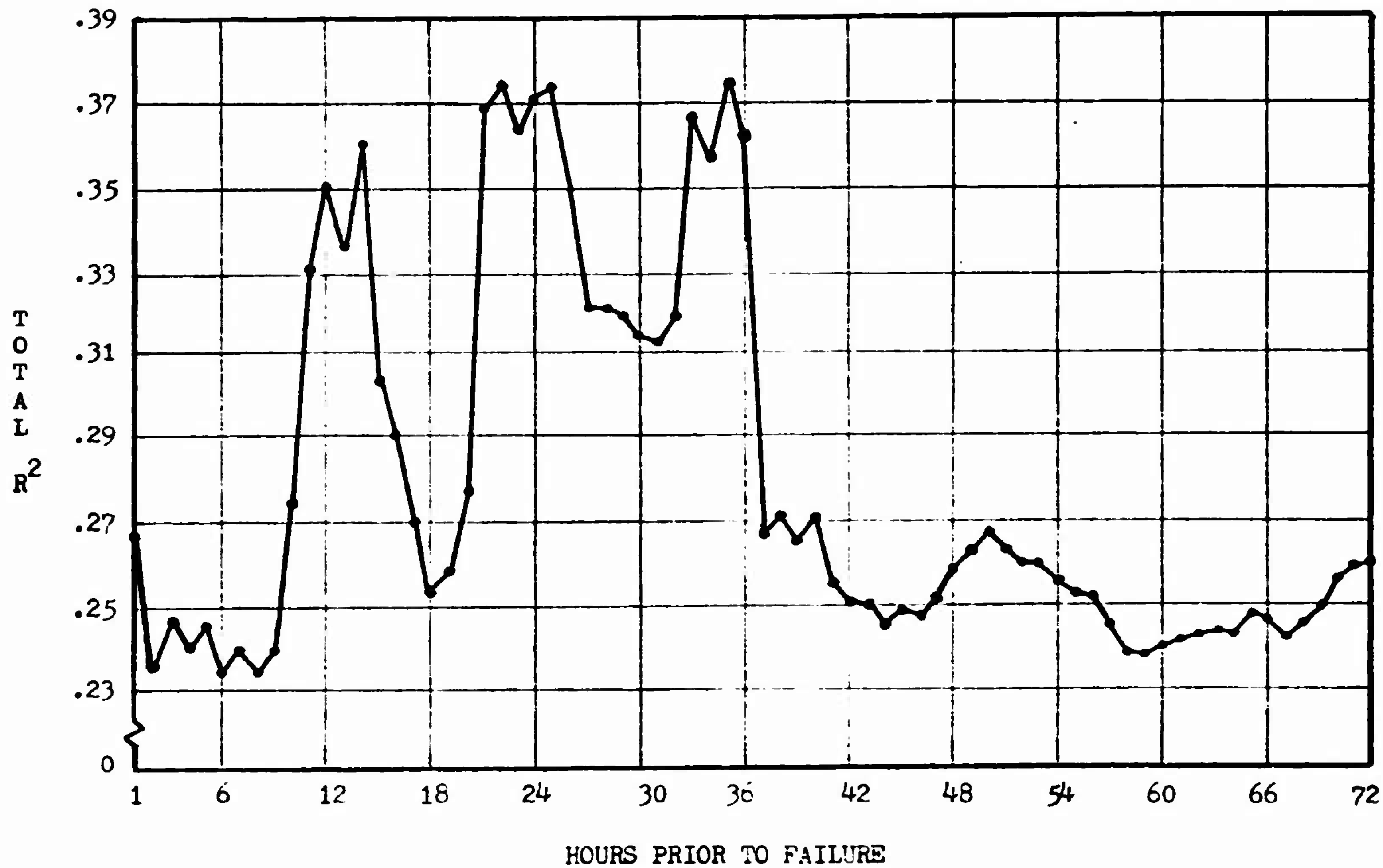


Figure 20. Failure Group Two vs. Environmental Group C

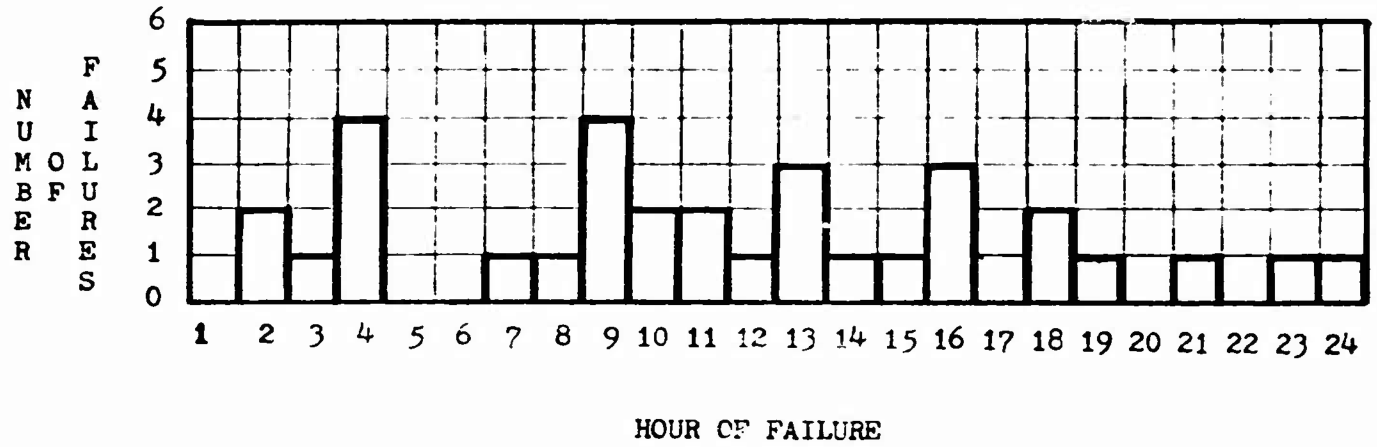


Figure 21. Time of Day vs. DCU Failure Rate

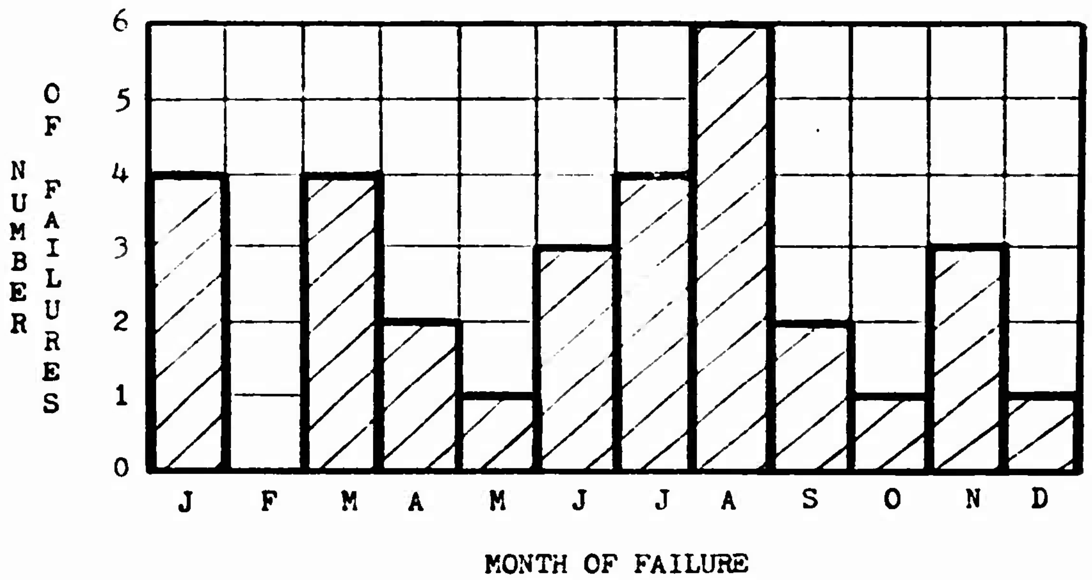


Figure 22. Month of Failure vs. DCU Failure Rate

Variable	% Contribution to R^2	Variable	% Contribution to R^2
T31	19	T321	42
T32	2	T322	45
T33	7	T323	49
T34	15	T324	53
T35	15	T325	61
T36	9	T326	49
T37	9	T327	18
T38	8	T328	18
T39	9	T329	16
T310	14	T330	15
T311	36	T331	15
T312	36	T332	16
T313	36	T333	38
T314	42	T334	38
T315	38	T335	50
T316	37	T336	51
T317	15	T337	12
T318	13	.	for hours 38-72 the contribution to R^2 ranged from 3 to 13%
T319	14	.	
T320	17	.	
		T372	

Figure 23. Contribution of Average Rate-of-Temperature Change Variable to R^2 for DCU Failures

periods where the rate-of-change variable contributed the most to R^2 were very clearly defined.

When the rate-of-temperature change variable become the major contributor to R^2, humidity normally became the second major contributor. During the time periods when the rate-of-temperature change variable was not a major contributor, wind speed and pressure contributed the most to R^2.

The maximum R^2 values for the three cycles noted in Figures 20 and 23 (pages 71 and 74 respectively), occurred at 14, 22, and 35 hours prior to the time of failure. The R^2 values for these periods were .3607, .3741 and .3738 respectively. In each case the average rate-of-temperature change variable and humidity at the time of failure were the major contributors to the R^2 value. Average rate-of-temperature change combined with humidity amounted to 78, 77, and 85 percent respectively of the total R^2 values of .3607, .3741, and .3738. The contribution of the average rate-of-temperature change variable alone equaled 42, 45, and 50 percent respectively of the total R^2 value.

Since the total R^2 value in equation 35 equaled .3738, it may be interpreted as meaning that the average rate-of-temperature change variable (computed at 35 hours prior to failure), plus environmental conditions at time of failure, explained 37.38 percent of the variance in

TBSF of DCUs. The TBSF for DCUs displayed more sensitivity to the average rate-of-temperature change variable and environmental conditions at time of failure than any other group analyzed.

Summary of Group Two Analysis

This group consistently indicated a greater sensitivity to external environmental conditions than any other group. When regressed against environmental Groups A and C, an inverse relationship was indicated between the temperature variable and TBSF. Wind speed and pressure were major contributors in all equations except where temperature variable T3 was dominant in the regression against environmental Group C. The highest R^2 value (.3741) was obtained during the Group two versus environmental Group C regression in equation 22.

Analysis of Group Three Equations

This group is analyzed as indicated in Figure 24. The first equation regresses the group three failures against environmental Group A. The next twelve equations regress group three failures against environmental Group B. The last 36 equations regress group three failures against environmental Group C.

Failure Group Three vs. Environmental Group A

See Appendix C-1. This regression indicated an inverse relationship between temperature/pressure at time

DEPENDENT VARIABLES (TBSF)	INDEPENDENT VARIABLES (ENVIRONMENTAL CONDITIONS)			TOTAL EQS.
	GROUP A	GROUP B	GROUP C	
GROUP THREE FAILURES (Stratified Population) PIGA Stratum	TEMP, WS, WD, H, P (T1)	TEMP, WS, WD, H, P ($T2_n$) n=6,12...72	TEMP, WS, WD, H, P ($T3_n$) n=1,2...36	49
	#Equations = 1 Appendix C-1	#Equations = 12 Appendix C-2, Eqs. 1-12	#Equations = 36 Appendix C-3, Eqs. 1-36	

Figure 24. Group Three Equations vs. Environmental Groups A, B, and C

of failure and TBSF due to PIGA malfunctions. The other variables (wind speed, wind direction and humidity) indicated a direct relationship with the TBSF of PIGAs. The major contributors to R^2 (.0485) were humidity (.0315), and temperature (.0138); pressure, wind direction and wind speed contributed .0032, .0000, and .0000 respectively. The total R^2 value was fairly low .0485, which may be interpreted as meaning that environmental conditions at time of failure explained 4.85 percent of the variance in the TBSF.

Failure Group Three vs. Environmental Group B

See Appendix C-2. All twelve regression equations in this grouping indicated an inverse relationship between the TBSF due to PIGA malfunctions and wind speed, barometric pressure and the average temperature variable. An inverse relationship was indicated between TBSF and wind direction for the first six equations. The last six equations indicated a direct relationship between TBSF and wind direction. All equations indicated a direct relationship between humidity and TBSF. The major contributors to R^2 were the average temperature variable, pressure and humidity. The combined contribution of these three variables accounted for more than 99 percent of R^2 (.0777-.0951) in all twelve equations.

Total R^2 values are plotted on the graph in Figure 25. The values of R^2 ranged from .0777 in equation eight

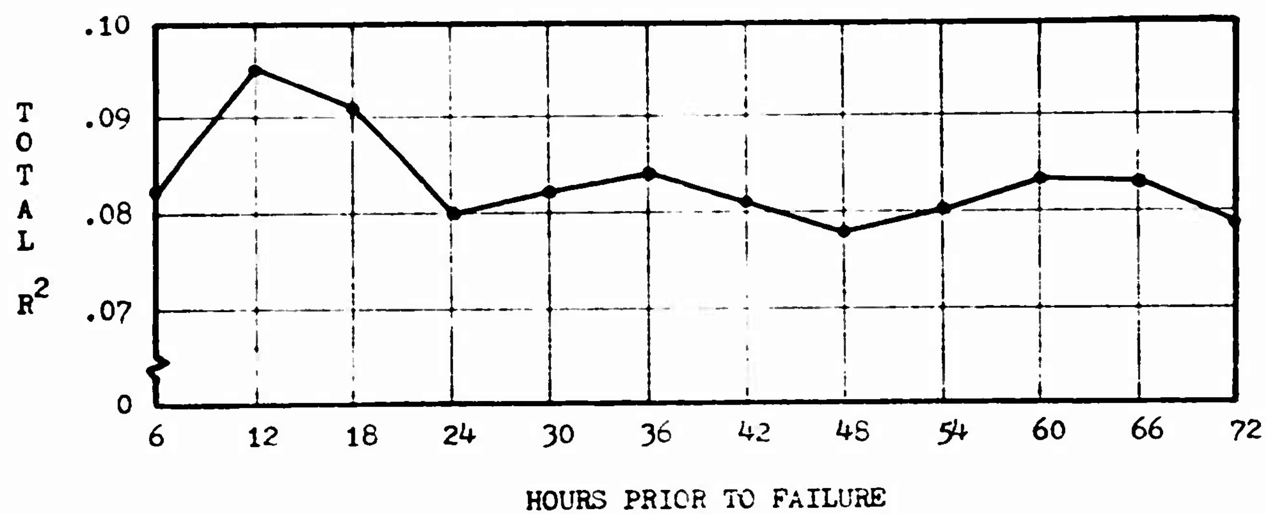


Figure 25. Failure Group Three vs. Environmental Group B

to a high of .0951 in equation two. This may be interpreted as meaning that from 7.77 to 9.51 percent of the variance in TBSF of PIGAs is explained by environmental conditions at time of failure, plus the average temperature variable.

Failure Group Three vs. Environmental Group C

See Appendix C-3. The original plan for this grouping was to compute twelve equations. However, equations nine, ten, eleven, and twelve indicated that a relationship was developing between TBSF and the average rate-of-temperature change variable. Of further interest was the fact that the average rate-of-temperature change variable contributed from 88 to 94 percent of the R^2 value in equations nine, ten, eleven, and twelve. Based on experience with the DCU failure rate analysis, an additional twenty-four equations were computed to determine if the relationship would continue to develop.

All of the equations indicated that an inverse relationship existed between TBSF and (1) the average rate-of-temperature change variable, (2) barometric pressure, and (3) wind speed (except equation thirteen). An inverse relationship was indicated between TBSF and wind direction in equations three, four, and twenty-four. All equations indicated a direct relationship between TBSF and humidity.

The average rate-of-temperature change variable was the major contributor to R^2 in equations three through twenty-four. In equation three it contributed 56 percent of the total R^2 value. In equations four through twenty-four, the average rate-of-temperature change variable contribution to R^2 ranged from 76 to 94 percent, with an average contribution of 85 percent. In equation one, two, and twenty-five through thirty-six, humidity was the major contributor to R^2. The contribution ranged from 53 to 97 percent with an average contribution of 88 percent. The most significant R^2 values occurred in equations twelve (.1610) and seventeen through twenty-two (.1414, .1500, .1554, .1584, .1358, and .1342, respectively). After equation twenty-two, the R^2 value dropped very sharply to a value of .0336 in equation twenty-five. See Figure 26. The value of R^2 remained at approximately the .0336 level through equation thirty-six. The total R^2 values are plotted on the graph in Figure 26. It was interesting that environmental conditions at the time of failure contributed very little to R^2 in this group of equations.

Since the R^2 value of the average rate-of-temperature change variable equaled .1518 in equation twelve, it may be interpreted as meaning that the average rate-of-temperature change variable (when computed at twelve hours prior to failure) explained 15.18 percent of the variance in TBSF of PIGAs.

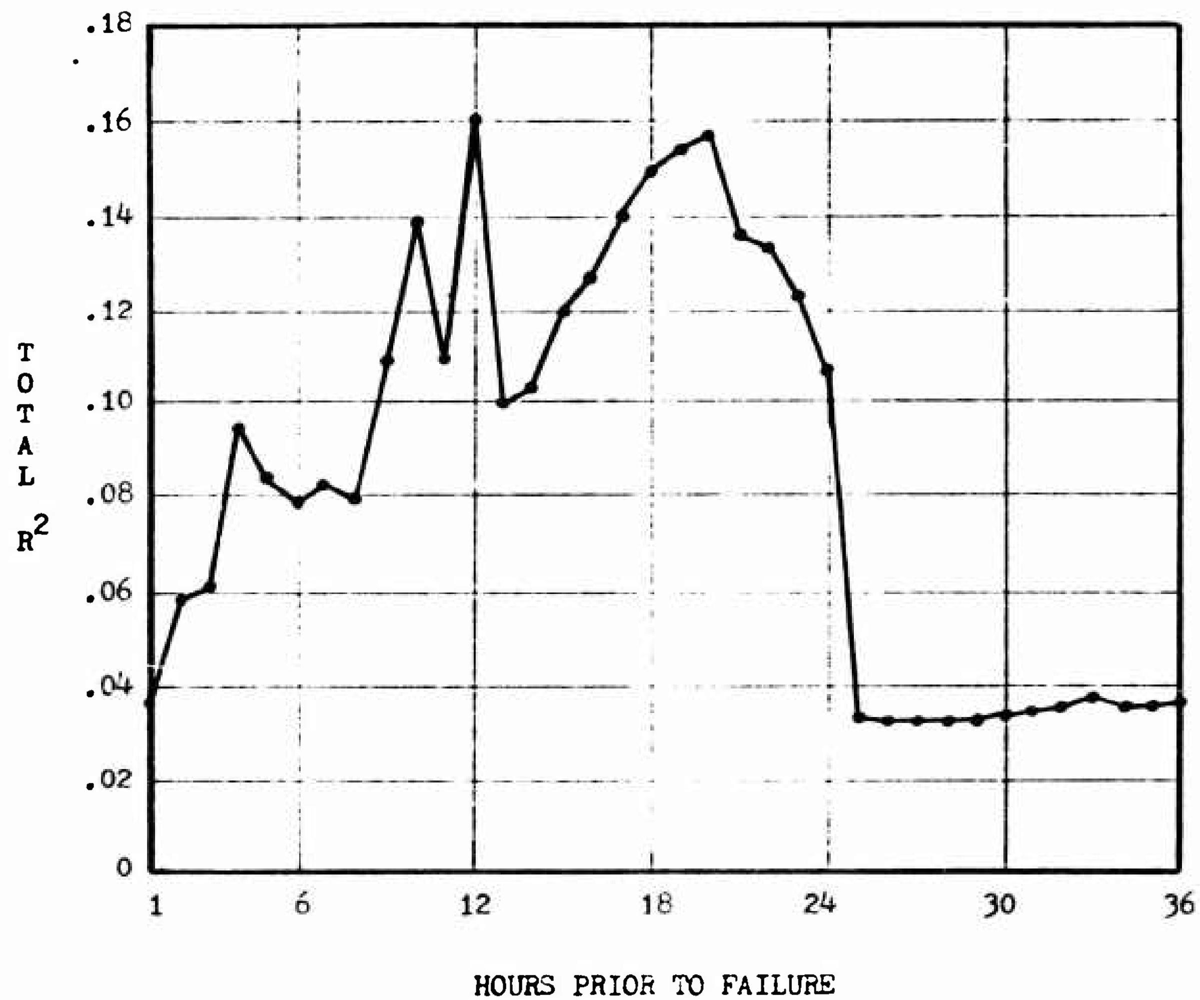


Figure 26. Failure Group Three vs. Environmental Group C

Summary of Group Three Analysis

The TBSF for this group displayed little sensitivity to external environmental conditions with the exception of the T3 variable. Temperature, pressure and wind speed were generally indicated as having an inverse relationship with TBSF. With the exception of the Group three versus environmental Group A regression, the temperature variable was the major contributor to R^2. The highest R^2 (.1610) value was obtained in equation twelve during the regression against environmental Group C.

Testing of Hypothesis

Introduction

The researchers desired a conservative approach to testing for support of the research hypothesis. Defining the data as being derived from a representative sample of a process population would have been tenuous. Therefore, the data, by definition, was a census of a small information finite population. As such, a statistical test was considered inappropriate as the first step in research hypothesis testing because conducting a statistical test on a population census and/or non-representative sample of an ill defined population, would violate the assumptions underlying the appropriate use of such tests. Those readers willing to assume the data was collected from a representative sample of an indeterminate population may

refer to Appendices A, B, and C for the results of statistical testing.

Construction of Decision Rule

To construct a decision rule it was necessary to present the results of the data analysis in Chapter IV to several individuals familiar with statistical methods and the NS-20 guidance system. Each individual was asked to specify a level of R^2 at which he would consider the results of the study to be of practical significance in terms of decision making and potential follow-up studies. Only personnel within the School of Systems and Logistics had access to the total study. Personnel outside the school gave their opinions based on an oral description of the research design and data analysis. The following paragraphs are brief summaries of interviews conducted by the authors.

Captain Steven Henderson, Quantitative Studies Department, School of Systems and Logistics. Captain Henderson believed that since the NS-20 is environmentally protected within the Minuteman silo, there should be no relationship between NS-20 failure rates and external environmental conditions. Therefore, in his opinion, any value of R^2 above zero would warrant further study (17).

Lieutenant Colonel Joseph Boyett, Management Studies Department, School of Systems and Logistics. In Lieutenant Colonel Boyett's experience with multiple

regression, almost any combination of variables would produce some value of R^2. Under the circumstances of this study, it was his opinion that any value of R^2 above .15 would warrant further study (10).

Mr. Robert Wallen, MER Ogden Air Logistics Center. Mr. Wallen believed that an R^2 value of .15 or higher should be considered significant. However, the R^2 value would have to range from .3 to .4 before the results could be considered of practical significance and warrant further study (27).

Mr. Russell Genet, AGMC. Mr. Genet believed any variable would produce an R^2 of some value. Considering the circumstances surrounding Minuteman NS-20 failures, it was his opinion that an R^2 value of .35 would be considered of practical significance and the results would warrant further study (13).

Decision Rule

Based on the background and experience of the above individuals, the most conservative estimates were selected as a basis for the decision rule. Therefore, any R^2 value that exceeded .35 was considered as being of practical significance. However, the reader should apply his own judgement in analyzing the results.

Testing of Hypothesis

The research hypothesis stated that a relationship existed between the TBSF of NS-20s and external environmental conditions. The search for a relationship consisted of the computation of 159 regression equations. These equations were the results of a regression analysis of the failure groups and environmental groups listed in Figure 27. Based on the decision rule established (Figure 27), the only multiple regression equations that produced R^2 values of practical significance were those where group two failures were regressed against environmental Group C. However, out of the 72 equations that were computed in regressing group two failures against environmental Group C, only eleven produced a significant R^2 value. The variables that were contained in the eleven equations are listed in Figure 28. The contribution to R^2 of each variable is in parenthesis. The equations are listed in Appendix B-3.

The research hypothesis that a relationship exists between the TBSF of NS-20s and external environmental conditions is supported. However, it is supported for only very limited combinations of independent variables, that include the variable "average rate-of-temperature change." Without the stepwise regression of other independent variables of wind speed, wind direction, pressure and humidity, the average rate-of-temperature change variable contributed an average of approximately 52 percent to the total R^2.

DEPENDENT VARIABLES (TBSF)	INDEPENDENT VARIABLES (ENVIRONMENTAL CONDITIONS)			TOTAL EQS.
	GROUP A	GROUP B	GROUP C	
GROUP ONE FAILURES (Non-strat Population)	TEMP, WS, WD, H, P (T1)	TEMP, WS, WD, H, P ($T2_n$) n=6,12...72	TEMP, WS, WD, H, P ($T3_n$) n=1,2...12	
	#Equations = 1 Appendix A-1	#Equations = 12 Appendix A-2	#Equations = 12 Appendix A-3	25
GROUP TWO FAILURES (Stratified Population) DCU Stratum	TEMP, WS, WD, H, P (T1)	TEMP, WS, WD, H, P ($T2_n$) n=6,12...72	TEMP, WS, WD, H, P ($T3_n$) n=1,2...72	
	#Equations = 1 Appendix B-1	#Equations = 12 Appendix B-2	# Equations = 72 Appendix B-3	85
GROUP THREE FAILURES (Stratified Population) PIGA Stratum	TEMP, WS, WD, H, P (T1)	TEMP, WS, WD, H, P ($T2_n$) n=6,12...72	TEMP, WS, WD, H, P ($T3_n$) n=1,2...36	
	#Equations = 1 Appendix C-1	#Equations = 12 Appendix C-2	#Equations =36 Appendix C-3	49
TOTAL EQUATIONS	3	36	120	159

Figure 27. Summary of Multiple Regression Equations

TEMPERATURE VARIABLE*	VARIABLES FOR CONDITIONS AT TIME OF FAILURE				TOTAL R^2
T312(.128)**	H(.124)	WD(.042)	P(.054)	WS(.002)	.350
T314(.153)	H(.130)	WD(.039)	P(.039)	WS(.001)	.360
T321(.155)	H(.108)	WD(.064)	P(.043)	WS(.000)	.368
T322(.167)	H(.119)	WD(.056)	P(.032)	WS(.000)	.374
T323(.178)	H(.117)	WD(.048)	P(.020)	WS(.001)	.363
T324(.198)	H(.117)	WD(.034)	P(.021)	WS(.001)	.371
T325(.227)	H(.093)	WD(.026)	P(.026)	WS(.000)	.313
T333(.139)	H(.130)	WD(.065)	P(.023)	WS(.009)	.366
T334(.136)	H(.127)	WD(.060)	P(.023)	WS(.011)	.356
T335(.187)	H(.131)	WD(.038)	P(.014)	WS(.003)	.374
T336(.184)	H(.123)	WD(.037)	P(.014)	WS(.005)	.361

*T312 represents the average rate-of-temperature change condition existing for twelve hours prior to failure; T314, 14 hours; T321, 21 hours, through 36 hours for T336.

**Contribution to R^2 is in parenthesis after each variable.

Figure 28. Equations Producing R^2 Values of .35 and Above

Humidity contributed an average of 33 percent. Due to the relationship between humidity and temperature (see Chapter III, "Environmental Variables"), there was concern that the relationship might be responsible for the large contribution to R^2 by humidity and the rate-of-temperature change variables. However, inspection of the data failed to reveal any obvious interaction between humidity and the rate-of-temperature change during the periods when practically significant R^2 values were achieved. The inspection consisted of a search for patterns in the correlation between humidity and the rate-of-temperature change; for evidence of multicollinearity between the two variables; and for variations in the mean and standard deviation of each average rate-of-temperature change variable. Although no relationships were obvious through inspection, it should not be concluded they do not exist. The relationship between the variables may be so complex that the only means of identifying them may be through the use of multiple regression or other mathematical techniques.

Since the stepwise addition of the independent variables may have created some association by chance, the findings of limited support should be accepted with caution. In general, the analysis indicated a lack of support in terms of practical significance except under some very limited conditions for DCU failures.

Overview

Chapter V contains conclusions, recommendations and a brief critique of this study.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to determine if a relationship existed between external environmental conditions and the TBSF of NS-20s at Grand Forks AFB, North Dakota. The study of environmental conditions versus NS-20 failures evolved as the result of the opinions of various maintenance and depot personnel that there seemed to be more NS-20 failures at certain times of the year. The preponderance of opinion was that the number of failures increased during spring and fall months. Several informal, undocumented studies had been conducted to determine if a relationship existed between the seasons of the year and failures of Minuteman guidance systems. None of the studies found a relationship.

If a seasonal variation in NS-20 failures existed, then it was possibly due to changes in external environmental conditions. Therefore this study was an attempt to determine if a relationship existed between the environmental conditions of temperature, wind speed, wind direction, humidity, barometric pressure and the failures of NS-20s. If a relationship between one or a combination of these environmental factors and NS-20 failures could be

found, it would be more meaningful than finding a relationship between the seasons and NS-20 failures. It was not the purpose of this study to determine why any particular relationship existed, but to simply determine if a relationship did exist. Therefore, the general approach was to conduct a search for a relationship through the use of multiple regression analysis. The search included examining both environmental conditions at the time of failure and prior to failure for all NS-20 failures and for specific NS-20 failure modes, i.e., DCU and PIGA malfunctions. The following paragraphs contain the conclusions and recommendations as a result of this study.

Conclusions

Under the criteria rule established in Chapter IV, the following conclusions are drawn from this study.

No relationship of practical importance existed between the TBSF of all NS-20 failures, non-stratified population, and any one or a combination of the following: (1) environmental conditions of temperature, wind speed, wind direction, humidity, and barometric pressure existing at the time of failure; (2) the average temperature conditions existing up to seventy-two hours prior to time of failure; and (3) the average rate-of-temperature change conditions existing up to twelve hours prior to time of failure.

No relationship of practical importance existed between the TBSF of NS-20s due to the stratum of PIGA malfunctions and any one or a combination of the following: (1) the environmental conditions of temperature, wind speed, wind direction, humidity and barometric pressure existing at the time of failure; (2) the average temperature conditions existing up to seventy-two hours prior to time of failure; and (3) the average rate-of-temperature change conditions existing up to thirty-six hours prior to the time of failure.

No relationship of practical importance existed between the TBSF of NS-20s due to the stratum of DCU malfunctions and any one or a combination of the following: (1) the environmental conditions of temperature, wind speed, wind direction, humidity and barometric pressure; and (2) the average temperature conditions existing for up to seventy-two hours prior to the time of failure.

A relationship of practical importance did exist between the TBSF of NS-20s due to the stratum of DCU malfunctions and a combination of environmental conditions existing at the time of failure; i.e., wind speed, wind direction, humidity, and barometric pressure, and the average rate-of-temperature change existing prior to failure. The specific combination is listed in Figure 28 on page 88.

The research hypothesis was supported. A relationship did exist between external environmental conditions and the NS-20 failure rate for DCU malfunctions. However, the relationship was for a very limited combination of environmental variables and DCU failures. Since DCU failures were the only category of NS-20 failures that indicated a significant sensitivity to environmental conditions, the possibility that their failure was related to the seasons of the year was examined. An inspection of Figure 22 on page 73, revealed that no obvious relationship existed between DCU-induced NS-20 failures and the seasons of the year.

Recommendations

One of the problems in using multiple regression analysis is knowing where to start. There seems to be no limit to the numbers, types, and combinations of variables that can be entered into the regression. Also, once the results of the regression equation are obtained, it can be very difficult to interpret their meaning or to determine precisely what the equation is measuring. This study should be considered as a preliminary and incomplete survey of the subject. If time permitted, or if this study could be replicated, the following changes should be made: (1) select a longer time period for analysis, i.e., three to four years so as to permit a time series analysis and provide a larger data base; (2) use a different combination

of variables in the regression equations; that is, combine all of the average rate-of-temperature change variables into one equation, rather than consider each one in a separate equation; (3) possibly re-define the average rate-of-temperature change variable and establish it as the total rate-of-temperature change variable and thus regress the total change in temperature change for the time periods used in this study against the TBSF; (4) conduct additional regressions, i.e., regress the failure rate against the time of day and the time of year; and (5) control the order in which the variables are considered in the regression equation rather than allowing the BMD02R program to establish the sequence by selecting the variables that contribute the most to R^2. When the researchers control the sequence in which independent variables are entered into the regression equation, a more precise analysis of the contribution of each variable is possible.

Therefore, additional studies conducted to more precisely define the relationships found in this study are recommended. If such relationships exist by trend, then additional studies should be conducted to determine why the relationships exist. Regression analysis provides a mathematical relationship. With enough equations and variables, by chance alone, some relationships may occur. However, these mathematical models should not

be interpreted as cause and effect relationships between dependent and independent variables.

The regression analysis indicated a possible relationship of practical significance associated with rate-of-temperature change and humidity. An inspection of the data was conducted to determine if a reasonable inference could be rendered about a possible cause and effect relationship. The inspection revealed that no obvious relationship exists.

APPENDICES

The appendices contain summaries of the 159 multiple regression equations. They also contain the computed programs to convert the raw data to usable form. Appendix A contains the equations from regressing the TBSF of failure group one against environmental groups A, B, and C. Appendix B contains the equations from regressing the TBSF of failure group three against environmental groups A, B, and C. Appendix D contains the computer programs to convert the raw data into usable form.

For readers who wish to consider this study as a representative sample of a process population, F-distribution values for given alpha levels (statistical significance) are included in Figure 29. The values in Figure 29 correspond to the appropriate upper and lower degrees of freedom of the equations included in each appendix. The terms SS and PS will be found next to the "F Ratio" on some equations. SS means the R^2 was statistically significant at the .05 level of confidence. PS means the R^2 was of practical significance; i.e., R^2 = .35 and above. If no symbol is present, the equation was not significant in either a statistical or practical sense. A detailed description of the BMD02R output is given in Chapter IV.

Preceding page blank

F-VALUES FOR APPENDIX A

ALPHA LEVEL	CONFIDENCE LEVEL	F-RATIO DF* = 5/153	F TO REMOVE DF = 1/153
.10	90	1.85	2.71
.05	95	2.21	3.84
.025	97.5	2.57	5.02
.01	99	3.02	6.63

F-VALUES FOR APPENDIX B

		DF = 5/25	DF = 1/25
.10	90	2.09	2.92
.05	95	2.60	4.24
.025	97.5	3.13	5.69
.01	99	3.85	7.77

F-VALUES FOR APPENDIX C

		DF = 5/71	DF = 1/71
.10	90	1.94	2.78
.05	95	2.36	3.99
.025	97.5	2.78	5.29
.01	99	3.33	7.07

*Degrees of freedom: upper = 5; lower = 153

Figure 29. F-Distribution Values for Appendices A, B, and C

APPENDIX A

FAILURE GROUP ONE (ALL NS-20 FAILURES) VERSUS ENVIRONMENTAL GROUPS A, B, AND C

This appendix is divided into three sub-appendices. Appendices A-1, A-2, and A-3 contain respectively the equations that resulted from regressing the TBSF of all NS-20 failures against environmental groups A, B, and C. The appropriated F-distribution values for each sub-appendix are listed in Figure 29 on page 99.

Preceding page blank

APPENDIX A-1

FAILURE GROUP ONE (ALL NS-20 FAILURES)

VERSUS ENVIRONMENTAL GROUP A

DF	F RATIO
5	0.421
153	

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	95.23852)		
TEMP 2	-0.21627	0.23883	0.6200 (3)
WD 3	0.02223	0.03975	0.3127 (3)
WS 4	0.46955	0.85263	0.3297 (3)
PRES 5	-1.43679	24.34966	0.0035 (3)
HUM 6	0.04109	0.30879	0.0177 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
TEMP 2		0.0919	0.0085
WS 4		0.1064	0.0113
WD 3		0.1155	0.0134
HUM 6		0.1164	0.0135
PRES 5		0.1165	0.0136

APPENDIX A-2

FAILURE GROUP ONE (ALL NS-20 FAILURES)

VERSUS ENVIRONMENTAL GROUP B

DF	F RATIO	
5	0.477	1
153		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		571.32090)		
WD	2	0.01969	0.03979	0.2447 (3)
WS	3	0.35286	0.85248	0.1706 (3)
PRES	4	-17.05360	24.10365	0.4984 (3)
HUM	5	-0.01151	0.29974	0.0015 (3)
T26	6	-0.23659	0.23833	1.4460 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
T26	6		0.0830	0.0069
PRES	4		0.1105	0.0122
WD	2		0.1187	0.0141
WS	3		0.1238	0.0153
HUM	5		0.1238	0.0153

DF	F RATIO	
5	0.481	2
153		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		506.82722)		
WD	2	0.02113	0.03964	0.2841 (3)
WS	3	0.34832	0.85263	0.1669 (3)
PRES	4	-16.98694	24.00445	0.4983 (3)
HUM	5	0.02278	0.29060	0.0061 (3)
T212	7	-0.29109	0.24018	1.4689 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
T212	7		0.0814	0.0066
PRES	4		0.1108	0.0123
WD	2		0.1200	0.0144
WS	3		0.1243	0.0154
HUM	5		0.1244	0.0155

3

DF	F RATIO
5	0.461
153	

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		544.74858)		
WD	2	0.02230	0.03957	0.3175 (3)
WS	3	0.33695	0.85399	0.1557 (3)
PRES	4	-16.27670	24.00797	0.4596 (3)
HUM	5	0.03221	0.28932	0.0124 (3)
T218	8	-0.28953	0.24749	1.3686 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
T218	8		0.0784	0.0061
PRES	4		0.1072	0.0115
WD	2		0.1176	0.0138
WS	3		0.1215	0.0148
HUM	5		0.1218	0.0148

4

DF	F RATIO
5	0.442
153	

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		519.33992)		
WD	2	0.02231	0.03959	0.3176 (3)
WS	3	0.33772	0.85447	0.1562 (3)
PRES	4	-15.43065	23.86801	0.4180 (3)
HUM	5	0.02923	0.29076	0.0101 (3)
T224	9	-0.28309	0.25068	1.2753 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
T224	9		0.0770	0.0059
PRES	4		0.1043	0.0109
WD	2		0.1150	0.0132
WS	3		0.1191	0.0142
HUM	5		0.1194	0.0142

5

DF	F RATIO
5	0.403
153	

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	474.67377)		
WD 2	0.02273	0.03961	0.3294 (3)
WS 3	0.33890	0.85563	0.1569 (3)
PRES 4	-13.99611	23.75602	0.3471 (3)
HUM 5	0.03650	0.29085	0.0157 (3)
T230 10	-0.25832	0.24840	1.0814 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T230 10		0.0719	0.0052
PRES 4		0.0978	0.0096
WD 2		0.1095	0.0120
WS 3		0.1136	0.0129
HUM 5		0.1140	0.0130

6

DF	F RATIO
5	0.388
153	

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	450.24450)		
WD 2	0.02336	0.03958	0.3483 (3)
WS 3	0.33331	0.85683	0.1513 (3)
PRES 4	-13.22277	23.60370	0.3138 (3)
HUM 5	0.04600	0.28923	0.0253 (3)
T236 11	-0.24659	0.24585	1.0060 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T236 11		0.0696	0.0048
PRES 4		0.0947	0.0090
WD 2		0.1073	0.0115
WS 3		0.1112	0.0124
HUM 5		0.1119	0.0125

7

DF	F RATIO
5	0.417
153	

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	472.18948)		
WD 2	0.02388	0.03952	0.3652 (3)
WS 3	0.31689	0.85751	0.1366 (3)
PRES 4	-13.92327	23.48929	0.3514 (3)
HUM 5	0.04255	0.28876	0.0217 (3)
T242 6	-0.26348	0.24561	1.1508 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T242 6		0.0743	0.0055
PRES 4		0.0995	0.0099
WD 2		0.1120	0.0125
WS 3		0.1154	0.0133
HUM 5		0.1160	0.0134

8

DF	F RATIO
5	0.416
153	

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	461.74673)		
WD 2	0.02418	0.03950	0.3748 (3)
WS 3	0.31556	0.85770	0.1354 (3)
PRES 4	-13.57374	23.32363	0.3387 (3)
HUM 5	0.03969	0.28944	0.0188 (3)
T248 7	-0.26103	0.24371	1.1471 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T248 7		0.0748	0.0056
PRES 4		0.0991	0.0098
WD 2		0.1119	0.0125
WS 3		0.1153	0.0133
HUM 5		0.1159	0.0134

DF	F RATIO	9
5	0.408	
153		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	447.79590)		
WD 2	0.02426	0.03951	0.3772 (3)
WS 3	0.31581	0.85806	0.1355 (3)
PRES 4	-13.12219	23.22661	0.3192 (3)
HUM 5	0.04070	0.28959	0.0197 (3)
T254 8	-0.25344	0.24123	1.1038 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T254 8		0.0740	0.0055
PRES 4		0.0976	0.0095
WD 2		0.1107	0.0122
WS 3		0.1141	0.0130
HUM 5		0.1147	0.0131

DF	F RATIO	10
5	0.400	
153		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	436.21175)		
WD 2	0.02437	0.03951	0.3804 (3)
WS 3	0.31459	0.85857	0.1343 (3)
PRES 4	-12.75647	23.15303	0.3036 (3)
HUM 5	0.04604	0.28866	0.0254 (3)
T260 9	-0.24755	0.23965	1.0669 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T260 9		0.0730	0.0053
PRES 4		0.0962	0.0093
WD 2		0.1096	0.0120
WS 3		0.1129	0.0127
HUM 5		0.1136	0.0129

11

DF	F RATIO
5	0.385
153	

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	417.85602)		
WD 2	0.02458	0.03951	0.3870 (3)
WS 3	0.31521	0.85929	0.1346 (3)
PRES 4	-12.16586	23.00828	0.2777 (3)
HUM 5	0.04883	0.23868	0.0286 (3)
T266 10	-0.23778	0.23891	0.9905 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T266 10		0.0708	0.0050
PRES 4		0.0933	0.0087
WD 2		0.1072	0.0115
WS 3		0.1106	0.0122
HUM 5		0.1115	0.0124

12

DF	F RATIO
5	0.361
153	

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	391.65424)		
WD 2	0.02462	0.03953	0.3879 (3)
WS 3	0.32205	0.85966	0.1403 (3)
PRES 4	-11.31981	23.02950	0.2416 (3)
HUM 5	0.05103	0.23929	0.0311 (3)
T272 11	-0.22280	0.23833	0.8739 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T272 11		0.0672	0.0045
PRES 4		0.0889	0.0079
WD 2		0.1035	0.0107
WS 3		0.1071	0.0115
HUM 5		0.1080	0.0117

APPENDIX A-3

FAILURE GROUP ONE (ALL NS-20 FAILURES)

VERSUS ENVIRONMENTAL GROUP C

DF	F RATIO
5	0.201
153	

1

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	33.90859)		
WD 2	0.02814	0.04014	0.4915 (3)
WS 3	0.46278	0.86001	0.2896 (3)
PRES 4	-0.00254	19.74655	0.0000 (3)
HUM 5	0.13553	0.23872	0.2204 (3)
T31 6	0.76251	2.71149	0.0791 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WD 2		0.0581	0.0034
WS 3		0.0694	0.0048
HUM 5		0.0776	0.0060
T31 6		0.0809	0.0065
PRES 4		[illegible]	[illegible]

DF	F RATIO
5	0.328
153	

2

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	139.90463)		
WD 2	0.02516	0.03953	0.4051 (3)
WS 3	0.30753	0.86485	0.1264 (3)
PRES 4	-3.03160	19.99411	0.0230 (3)
HUM 5	0.03763	0.29615	0.0161 (3)
T32 7	-2.88298	3.42600	0.7081 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T32 7		0.0790	0.0062
WD 2		0.0963	0.0093
WS 3		0.1013	0.0103
PRES 4		0.1025	0.0105
HUM 5		0.1030	0.0106

3

DF	F RATIO
5	0.953
153	

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		231.12872)		
WD	2	0.02303	0.03915	0.3460 (3)
WS	3	0.14658	0.85605	0.0293 (3)
PRES	4	-7.13107	19.82787	0.1293 (3)
HUM	5	-0.08650	0.29680	0.0849 (3)
T33	8	-7.46569	3.82339	3.8128 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
T33	8		0.1609	0.0259
WD	2		0.1686	0.0285
PRES	4		0.1711	0.0293
HUM	5		0.1732	0.0300
WS	3		0.1738	0.0302

4

DF	F RATIO
5	1.279
153	

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		324.46729)		
WD	2	0.02736	0.03892	0.4944 (3)
WS	3	0.00316	0.35907	0.0000 (3)
PRES	4	-8.24032	19.71053	0.1748 (3)
HUM	5	-0.17502	0.30352	0.3325 (3)
T34	9	-9.70350	4.16167	5.4365 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
T34	9		0.1841	0.0339
WD	2		0.1932	0.0373
HUM	5		0.1973	0.0389
PRES	4		0.2003	0.0401
WS	3		0.2003	0.0401

DF	F RATIO	5
5	1.100	
153		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	319.57935)		
WD 2	0.02879	0.03904	0.5436 (3)
WS 3	0.02176	0.80325	0.0006 (3)
PRES 4	-8.10911	19.81233	0.1675 (3)
HUM 5	-0.17248	0.30872	0.3121 (3)
T35 10	-9.54471	4.47671	4.5458 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T35 10		0.1679	0.0282
WD 2		0.1788	0.0320
HUM 5		0.1831	0.0335
PRES 4		0.1863	0.0347
WS 3		0.1863	0.0347

DF	F RATIO	6
5	0.920	
153		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	315.31972)		
WD 2	0.03039	0.03920	0.0011 (3)
WS 3	0.07120	0.86482	0.0068 (3)
PRES 4	-8.05735	19.94693	0.1632 (3)
HUM 5	-0.15809	0.31312	0.2549 (3)
T36 11	-9.20059	4.81516	3.6510 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T36 11		0.1498	0.0224
WD 2		0.1631	0.0266
HUM 5		0.1670	0.0279
PRES 4		0.1707	0.0292
WS 3		0.1709	0.0292

7

DF	F RATIO
5	0.638
153	

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		266.01449)		
WD	2	0.03149	0.03947	0.6368 (3)
WS	3	0.09092	0.87778	0.0107 (3)
PRES	4	-6.54189	20.05839	0.1064 (3)
HUM	5	-0.13477	0.32566	0.1710 (3)
T37	6	-8.11810	5.41123	2.2507 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
T37	6		0.1190	0.0142
WD	2		0.1362	0.0185
HUM	5		0.1396	0.0195
PRES	4		0.1427	0.0204
WS	3		0.1430	0.0204

8

DF	F RATIO
5	0.488
153	

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		250.26311)		
WD	2	0.03092	0.03959	0.6100 (3)
WS	3	0.11814	0.88764	0.0177 (3)
PRES	4	-6.14235	20.24609	0.0920 (3)
HUM	5	-0.10207	0.33213	0.0944 (3)
T38	7	-7.26148	5.91993	1.5046 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
T38	7		0.0999	0.0100
WD	2		0.1193	0.0142
WS	3		0.1217	0.0148
HUM	5		0.1229	0.0151
PRES	4		0.1253	0.0157

DF	F RATIO	9
5	0.839	
153		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		338.54329)		
WD	2	0.03083	0.03927	0.6164 (3)
WS	3	-0.10302	0.89577	0.0132 (3)
PRES	4	-8.57284	20.08933	0.1821 (3)
HUM	5	-0.20797	0.33172	0.3930 (3)
T39	8	-11.03259	6.12203	3.2476 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
T39	8		0.1402	0.0196
WD	2		0.1539	0.0237
HUM	5		0.1598	0.0255
PRES	4		0.1631	0.0266
WS	3		0.1634	0.0267

DF	F RATIO	10
5	1.292	
153		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		474.21698)		
WD	2	0.03315	0.03902	0.7217 (3)
WS	3	-0.26799	0.89056	0.0906 (3)
PRES	4	-12.73125	20.12684	0.4001 (3)
HUM	5	-0.27749	0.32358	0.7354 (3)
T310	9	-14.49117	6.17890	5.5003 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
T310	9		0.1750	0.0306
WD	2		0.1873	0.0351
HUM	5		0.1948	0.0379
PRES	4		0.1999	0.0400
WS	3		0.2013	0.0405

DF	F RATIO	11
5	1.006	
153		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	398.93908)		
WD 2	0.03030	0.03913	0.5994 (3)
WS 3	-0.11097	0.88472	0.0157 (3)
PRES 4	-10.49511	20.14883	0.2713 (3)
HUM 5	-0.20801	0.32097	0.4200 (3)
T311 10	-12.61530	6.24822	4.0765 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T311 10		0.1561	0.0244
WD 2		0.1684	0.0283
HUM 5		0.1735	0.0301
PRES 4		0.1781	0.0317
WS 3		0.1784	0.0318

DF	F RATIO	12
5	1.679	
153		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	458.63345)		
WD 2	0.02943	0.03869	0.5786 (3)
WS 3	-0.31929	0.87839	0.1321 (3)
PRES 4	-11.96850	19.76428	0.3667 (3)
HUM 5	-0.29710	0.31400	0.8953 (3)
T312 11	-17.22184	6.32164	7.4216 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T312 11		0.2054	0.0422
HUM 5		0.2145	0.0460
WD 2		0.2225	0.0495
PRES 4		0.2263	0.0512
WS 3		0.2281	0.0520

APPENDIX B

FAILURE GROUP TWO (DCU FAILURES)
VERSUS ENVIRONMENTAL GROUPS A, B, AND C

This appendix is divided into three sub-appendices. Appendices B-1, B-2, and B-3 contain respectively the equations that resulted from regressing the TBSF due to DCU failures against environmental groups A, B, and C. The appropriate F-distribution values for each appendix are listed in Figure 29 on page 99.

Preceding page blank

APPENDIX B-1

FAILURE GROUP TWO (DCU FAILURES)

VERSUS ENVIRONMENTAL GROUP A

DF	F RATIO
5	1.526
25	

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	11969.23804)		
TEMP 2	-0.15156	2.43933	0.0039 (3)
WD 3	0.32698	0.34501	0.8982 (3)
WS 4	14.43098	7.46908	3.7330 (3)
PRES 5	400.74868	274.51771	2.1311 (3)
HUM 6	0.63772	3.23695	0.0388 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 4		0.3260	0.1063
PRES 5		0.4534	0.2056
WD 3		0.4800	0.2304
HUM 6		0.4835	0.2337
TEMP 2		0.4836	0.2338

APPENDIX B-2

FAILURE GROUP TWO (DCU FAILURES)

VERSUS ENVIRONMENTAL GROUP B

DF	F RATIO
5	1.374
25	

1

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	11470.84839)		
WD 2	0.35163	0.35318	0.9912 (3)
WS 3	15.09865	7.71213	3.8329 (3)
PRES 4	382.50310	279.80133	1.8688 (3)
HUM 5	0.99200	2.99619	0.1096 (3)
T26 6	0.26609	2.45339	0.0118 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4242	0.1800
WD 2		0.4601	0.2117
HUM 5		0.4638	0.2151
T26 6		0.4642	0.2155

DF	F RATIO
5	1.373
25	

2

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	11471.04565)		
WD 2	0.35007	0.35886	0.9516 (3)
WS 3	15.07951	7.70542	3.8298 (3)
PRES 4	382.64048	284.18671	1.8129 (3)
HUM 5	0.94847	2.81614	0.1134 (3)
T212 7	0.26156	2.55275	0.0105 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4242	0.1800
WD 2		0.4601	0.2117
HUM 5		0.4638	0.2151
T212 7		0.4642	0.2155

3

DF	F RATIO
5	1.374
25	

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		11508.02966)		
WD	2	0.34894	0.35755	0.9524 (3)
WS	3	15.13811	7.75622	3.8093 (3)
PRES	4	363.72797	279.97529	1.8765 (3)
HUM	5	0.97372	2.83029	0.1184 (3)
T218	8	0.31204	2.65789	0.0138 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4242	0.1800
WD	2		0.4601	0.2117
HUM	5		0.4638	0.2151
T218	8		0.4643	0.2156

4

DF	F RATIO
5	1.374
25	

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		11441.56213)		
WD	2	0.35049	0.35603	0.9691 (3)
WS	3	15.14413	7.88226	3.6914 (3)
PRES	4	381.49496	275.70351	1.9147 (3)
HUM	5	0.97853	2.92618	0.1118 (3)
T224	9	0.29743	2.75045	0.0117 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4242	0.1800
WD	2		0.4601	0.2117
HUM	5		0.4638	0.2151
T224	9		0.4642	0.2155

DF	F RATIO	5
5	1.389	
25		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	12096.72241)		
WD 2	0.33286	0.35761	0.8664 (3)
WS 3	15.78130	8.05877	3.8348 (3)
PRES 4	402.07244	277.19088	2.1040 (3)
HUM 5	1.24607	2.92558	0.1814 (3)
T230 10	0.73133	2.73788	0.0714 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4242	0.1800
WD 2		0.4601	0.2117
HUM 5		0.4638	0.2151
T230 10		0.4662	0.2174

DF	F RATIO	6
5	1.388	
25		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	12094.49646)		
WD 2	0.32912	0.36317	0.8213 (3)
WS 3	15.86687	8.26811	3.6827 (3)
PRES 4	402.11712	278.91732	2.0785 (3)
HUM 5	1.21084	2.87559	0.1773 (3)
T236 11	0.71603	2.75506	0.0675 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4242	0.1800
WD 2		0.4601	0.2117
HUM 5		0.4638	0.2151
T236 11		0.4661	0.2173

7

DF	F RATIO
5	1.377
25	

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	11671.88000)		
WD 2	0.33966	0.36686	0.8572 (3)
WS 3	15.48507	8.35420	3.4357 (3)
PRES 4	388.76892	277.51385	1.9625 (3)
HUM 5	1.05797	2.88828	0.1342 (3)
T242 6	0.45251	2.79585	0.0262 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4242	0.1800
WD 2		0.4601	0.2117
HUM 5		0.4638	0.2151
T242 6		0.4647	0.2160

8

DF	F RATIO
5	1.375
25	

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	11508.10547)		
WD 2	0.34396	0.36763	0.8754 (3)
WS 3	15.35022	8.40482	3.3356 (3)
PRES 4	383.55877	274.46516	1.9529 (3)
HUM 5	1.00751	2.90822	0.1200 (3)
T248 7	0.35565	2.78302	0.0163 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4242	0.1800
WD 2		0.4601	0.2117
HUM 5		0.4638	0.2151
T248 7		0.4644	0.2156

DF	F RATIO	9
5	1.380	
25		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		11751.34680)		
WD	2	0.33422	0.36910	0.8199 (3)
WS	3	15.66540	8.47026	3.4205 (3)
PRES	4	391.17283	273.70270	2.0426 (3)
HUM	5	1.10754	2.88310	0.1476 (3)
T254	8	0.53316	2.75359	0.0375 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4242	0.1800
WD	2		0.4601	0.2117
HUM	5		0.4638	0.2151
T254	8		0.4651	0.2163

DF	F RATIO	10
5	1.381	
25		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		11788.00964)		
WD	2	0.33265	0.37003	0.8082 (3)
WS	3	15.71444	8.50800	3.4115 (3)
PRES	4	392.35667	274.28170	2.0463 (3)
HUM	5	1.11026	2.85680	0.1510 (3)
T260	9	0.55705	2.76731	0.0405 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4242	0.1800
WD	2		0.4601	0.2117
HUM	5		0.4638	0.2151
T260	9		0.4652	0.2164

DF	F RATIO	11
5	1.381	
25		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	11795.20264)		
WD 2	0.33206	0.36990	0.8059 (3)
WS 3	15.73076	8.49577	3.4284 (3)
PRES 4	392.55364	273.54086	2.0595 (3)
HUM 5	1.11727	2.85662	0.1530 (3)
T266 10	0.57304	2.78411	0.0424 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4242	0.1800
WD 2		0.4601	0.2117
HUM 5		0.4638	0.2151
T266 10		0.4653	0.2165

DF	F RATIO	12
5	1.379	
25		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	11683.69312)		
WD 2	0.33625	0.36858	0.8323 (3)
WS 3	15.59831	8.44262	3.4135 (3)
PRES 4	389.02855	272.20783	2.0425 (3)
HUM 5	1.08151	2.86586	0.1424 (3)
T272 11	0.49724	2.74789	0.0327 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4242	0.1800
WD 2		0.4601	0.2117
HUM 5		0.4638	0.2151
T272 11		0.4649	0.2162

APPENDIX B-3

FAILURE GROUP TWO (DCU FAILURES)

VERSUS ENVIRONMENTAL GROUP C

DF	F RATIO	1
5	1.825	
25		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		12403.68164)		
WD	2	0.19889	0.35090	0.3213 (3)
WS	3	11.56521	7.36196	2.4764 (3)
PRES	4	420.35905	235.63884	3.1823 (3)
HUM	5	-0.13154	2.45109	0.0029 (3)
T31	6	-33.43836	31.21701	1.1474 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4534	0.2056
T31	6		0.5060	0.2561
WD	2		0.5170	0.2673
HUM	5		0.5171	0.2674

DF	F RATIO	2
5	1.546	
25		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		12205.87097)		
WD	2	0.30412	0.34452	0.7792 (3)
WS	3	13.85239	7.42048	3.4849 (3)
PRES	4	409.67033	240.35886	2.9050 (3)
HUM	5	0.46636	2.58540	0.0325 (3)
T32	7	-9.02035	31.51344	0.0819 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4534	0.2056
WD	2		0.4800	0.2304
T32	7		0.4850	0.2352
HUM	5		0.4860	0.2362

3

DF	F RATIO
5	1.638
25	

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	12261.56763)		
WD 2	0.30755	0.33667	0.8345 (3)
WS 3	13.50298	7.09607	3.6210 (3)
PRES 4	413.73078	238.79049	3.0019 (3)
HUM 5	-0.08794	2.67602	0.0011 (3)
T33 8	-22.54445	34.25118	0.4332 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4534	0.2056
WD 2		0.4800	0.2304
T33 8		0.4967	0.2467
HUM 5		0.4968	0.2468

4

DF	F RATIO
5	1.578
25	

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	12360.81921)		
WD 2	0.32890	0.33767	0.9488 (3)
WS 3	13.62233	7.26381	3.5170 (3)
PRES 4	416.50857	240.36741	3.0026 (3)
HUM 5	-0.02895	2.95079	0.0001 (3)
T34 9	-18.76373	41.82407	0.2013 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4534	0.2056
WD 2		0.4800	0.2304
T34 9		0.4897	0.2398
HUM 5		0.4897	0.2398

DF	F RATIO	5
5	1.632	
25		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	11912.37134)		
WD 2	0.34050	0.33713	1.0201 (3)
WS 3	13.05679	7.30825	3.1919 (3)
PRES 4	403.20482	238.95172	2.8473 (3)
HUM 5	-0.51757	3.08433	0.0282 (3)
T35 10	-27.00525	42.11830	0.4111 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4534	0.2056
WD 2		0.4800	0.2304
T35 10		0.4953	0.2453
HUM 5		0.4961	0.2461

DF	F RATIO	6
5	1.526	
25		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	12176.20557)		
WD 2	0.32596	0.34664	0.8842 (3)
WS 3	14.49412	7.41073	3.8253 (3)
PRES 4	407.41218	243.56631	2.7979 (3)
HUM 5	0.69100	3.11949	0.0491 (3)
T36 11	-1.98797	47.98270	0.0017 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4534	0.2056
WD 2		0.4800	0.2304
HUM 5		0.4835	0.2337
T36 11		0.4835	0.2338

DF	F RATIO
5	1.576
25	

7

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	-8874.11255)		
WD 2	0.37144	0.33675	1.2166 (3)
WS 3	10.82752	8.31243	1.6967 (3)
PRES 4	305.44662	252.82656	1.4596 (3)
HUM 5	-1.53568	3.51154	0.1913 (3)
T37 6	-50.20396	55.95606	0.8050 (3)

VARIABLE ENTERED	REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4242	0.1800
WD 2		0.4601	0.2117
T37 6		0.4835	0.2338
HUM 5		0.4895	0.2396

DF	F RATIO
5	1.527
25	

8

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	-9897.68823)		
WD 2	0.39413	0.34041	1.3405 (3)
WS 3	10.92027	8.62483	1.6031 (3)
PRES 4	338.53461	246.79499	1.8816 (3)
HUM 5	-1.14839	3.43339	0.1119 (3)
T38 7	-45.83669	58.55040	0.6129 (3)

VARIABLE ENTERED	REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4242	0.1800
WD 2		0.4601	0.2117
T38 7		0.4801	0.2305
HUM 5		0.4837	0.2339

9

DF	F RATIO
5	1.578
25	

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		-9699.21802)		
WD	2	0.42455	0.34375	1.5254 (3)
WS	3	8.33184	10.04340	0.6882 (3)
PRES	4	334.33417	245.80939	1.8500 (3)
HUM	5	-1.55325	3.51645	0.1951 (3)
T39	8	-62.17752	68.96743	0.8128 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4242	0.1800
WD	2		0.4601	0.2117
T39	8		0.4837	0.2339
HUM	5		0.4897	0.2399

10

DF	F RATIO
5	1.891
25	

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		10495.67847)		
WD	2	0.35965	0.32876	1.1967 (3)
WS	3	6.67518	8.91892	0.5601 (3)
PRES	4	363.47253	237.35262	2.3451 (3)
HUM	5	-1.82850	2.94769	0.3848 (3)
T310	9	-80.86333	56.56562	2.0436 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4242	0.1800
T310	9		0.4673	0.2184
WD	2		0.5131	0.2633
HUM	5		0.5239	0.2744

DF	F RATIO		11
5	2.364		
25			

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	-9642.53760)		
WD 2	0.33682	0.31826	1.1200 (3)
WS 3	3.07085	8.91629	0.1186 (3)
PRES 4	341.76632	229.96889	2.2086 (3)
HUM 5	-3.27479	3.03726	1.1625 (3)
T311 10	-122.02665	61.78735	3.9004 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T311 10		0.3423	0.1172
HUM 5		0.4797	0.2301
PRES 4		0.5356	0.2869
WD 2		0.5638	0.3178
WS 3		0.5666	0.3211

DF	F RATIO	(PS,SS)	12
5	2.690		
25			

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	-9259.74036)		
WD 2	0.38996	0.31147	1.5675 (3)
WS 3	2.12348	8.56757	0.0614 (3)
PRES 4	330.86786	225.26571	2.1573 (3)
HUM 5	-3.68982	2.94137	1.5737 (3)
T312 11	-140.78954	61.87227	5.1778 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T312 11		0.3571	0.1275
HUM 5		0.5017	0.2517
PRES 4		0.5530	0.3058
WD 2		0.5901	0.3482
WS 3		0.5914	0.3498

DF F RATIO 13
5 2.527
25

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		-9702.16760)		
WD	2	0.33384	0.31484	1.1244 (3)
WS	3	4.46107	8.17637	0.2977 (3)
PRES	4	343.22371	227.39371	2.2782 (3)
HUM	5	-3.25605	2.91335	1.2491 (3)
T313	6	-122.77874	57.64129	4.5371 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
T313	6		0.3500	0.1225
HUM	5		0.4943	0.2443
PRES	4		0.5448	0.2968
WD	2		0.5725	0.3278
WS	3		0.5794	0.3357

DF F RATIO (PS,SS) 14
5 2.821
25

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		-7512.20691)		
WD	2	0.38114	0.30870	1.5243 (3)
WS	3	1.34296	8.57112	0.0245 (3)
PRES	4	272.32750	226.36658	1.4473 (3)
HUM	5	-3.83543	2.90735	1.7403 (3)
T314	7	-133.56136	55.97444	5.6935 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
T314	7		0.3905	0.1525
HUM	5		0.5316	0.2827
WD	2		0.5669	0.3214
PRES	4		0.6001	0.3601
WS	3		0.6006	0.3607

DF	F RATIO	15
5	2.181	
25		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		-6086.90063)		
WD	2	0.47137	0.32792	2.0662 (3)
WS	3	4.27367	8.95498	0.2278 (3)
PRES	4	219.18761	247.05230	0.7871 (3)
HUM	5	-2.63553	2.96747	0.7888 (3)
T315	8	-107.01721	60.00799	3.1805 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
T315	8		0.3378	0.1141
HUM	5		0.4645	0.2158
WD	2		0.5307	0.2816
PRES	4		0.5453	0.2974
WS	3		0.5511	0.3037

DF	F RATIO	16
5	2.040	
25		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		-6685.83057)		
WD	2	0.45994	0.33092	1.9318 (3)
WS	3	5.03403	9.08601	0.3070 (3)
PRES	4	237.53960	248.26248	0.9155 (3)
HUM	5	-2.21573	2.94252	0.5670 (3)
T316	9	-97.52298	60.16815	2.6271 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
T316	9		0.3292	0.1083
WD	2		0.4528	0.2050
HUM	5		0.5131	0.2632
PRES	4		0.5301	0.2811
WS	3		0.5383	0.2898

DF	F RATIO	17
5	1.835	
25		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	-7809.10669)		
WD 2	0.49349	0.34432	2.0541 (3)
WS 3	6.66004	9.16293	0.5283 (3)
PRES 4	274.95858	248.10474	1.2282 (3)
HUM 5	-2.43706	3.33101	0.5353 (3)
T317 10	-94.07183	69.66588	1.8234 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4242	0.1800
WD 2		0.4601	0.2117
T317 10		0.5028	0.2528
HUM 5		0.5182	0.2685

DF	F RATIO	18
5	1.697	
25		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	-9120.29688)		
WD 2	0.45801	0.34426	1.7701 (3)
WS 3	7.43564	9.53203	0.6085 (3)
PRES 4	316.53554	245.02683	1.6689 (3)
HUM 5	-1.83006	3.29415	0.3086 (3)
T318 11	-81.78881	72.22358	1.2824 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4242	0.1800
WD 2		0.4601	0.2117
T318 11		0.4942	0.2442
HUM 5		0.5034	0.2534

DF	F RATIO	
5	1.740	19
25		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		-9242.25525)		
WD	2	0.45441	0.34130	1.7727 (3)
WS	3	7.13067	9.42388	0.5725 (3)
PRES	4	321.46496	243.09021	1.7488 (3)
HUM	5	-2.04168	3.31493	0.3793 (3)
T319	6	-86.04441	71.43304	1.4509 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4242	0.1800
WD	2		0.4601	0.2117
T319	6		0.4969	0.2469
HUM	5		0.5081	0.2582

DF	F RATIO	
5	1.915	20
25		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		-8478.42981)		
WD	2	0.49252	0.34024	2.0954 (3)
WS	3	5.71962	9.25378	0.3820 (3)
PRES	4	298.25800	241.69522	1.5228 (3)
HUM	5	-2.53767	3.24000	0.6134 (3)
T320	7	-104.39118	71.38833	2.1383 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4242	0.1800
WD	2		0.4601	0.2117
T320	7		0.5092	0.2592
HUM	5		0.5263	0.2770

DF	F RATIO	(PS,SS)	21
5	2.916		
25			

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		-7606.58032)		
WD	2	0.49511	0.31152	2.5260 (3)
WS	3	0.24721	8.72222	0.0008 (3)
PRES	4	275.27952	224.62795	1.5018 (3)
HUM	5	-3.37636	2.73849	1.5201 (3)
T321	8	-159.46048	64.74995	6.0650 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
T321	8		0.3931	0.1545
HUM	5		0.5120	0.2622
WD	2		0.5707	0.3256
PRES	4		0.6069	0.3683
WS	3		0.6069	0.3684

DF	F RATIO	(PS,SS)	22
5	2.989		
25			

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		-6203.98969)		
WD	2	0.46508	0.30811	2.2785 (3)
WS	3	-0.39028	8.78169	0.0020 (3)
PRES	4	229.65233	227.17914	1.0219 (3)
HUM	5	-3.77376	2.80630	1.8083 (3)
T322	9	-163.88809	65.03493	6.3504 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
T322	9		0.4087	0.1670
HUM	5		0.5352	0.2864
WD	2		0.5852	0.3425
PRES	4		0.6116	0.3741
WS	3		0.6117	0.3741

DF F RATIO (PS,SS) 23
5 2.851
25

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	-5564.53522)		
WD 2	0.41940	0.30895	1.8427 (3)
WS 3	1.89664	8.37645	0.0513 (3)
PRES 4	206.42898	232.26236	0.7899 (3)
HUM 5	-3.29763	2.74810	1.4399 (3)
T323 10	-149.62436	62.07831	5.8093 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T323 10		0.4214	0.1776
HUM 5		0.5423	0.2941
WD 2		0.5850	0.3423
PRES 4		0.6015	0.3618
WS 3		0.6026	0.3631

DF F RATIO (PS,SS) 24
5 2.950
25

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	-5602.67047)		
WD 2	0.35564	0.30610	1.3499 (3)
WS 3	1.49466	8.33994	0.0321 (3)
PRES 4	208.88063	230.04665	0.8245 (3)
HUM 5	-3.38793	2.72651	1.5440 (3)
T324 11	-158.92526	63.83888	6.1975 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T324 11		0.4452	0.1982
HUM 5		0.5616	0.3154
WD 2		0.5908	0.3490
PRES 4		0.6085	0.3702
WS 3		0.6091	0.3711

DF	F RATIO	(PS,SS)	25
5	2.977		
25			

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	-5847.94592)		
WD 2	0.31222	0.30620	1.0398 (3)
WS 3	-0.44046	8.81443	0.0025 (3)
PRES 4	217.33734	228.63071	0.9036 (3)
HUM 5	-3.09465	2.64484	1.3691 (3)
T325 6	-160.42488	63.89925	6.3031 (3)

VARIABLE ENTERED	REMOVED	MULTIPLE R	RSQ
T325 6		0.4761	0.2267
HUM 5		0.5650	0.3193
PRES 4		0.5891	0.3471
WD 2		0.6108	0.3731
WS 3		0.6109	0.3732

DF	F RATIO	(SS)	26
5	2.679		
25			

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	-7495.62506)		
WD 2	0.35472	0.31145	1.2972 (3)
WS 3	4.64297	7.90763	0.3447 (3)
PRES 4	269.11807	229.03855	1.3806 (3)
HUM 5	-2.64882	2.66131	0.9906 (3)
T326 7	-144.09188	63.58581	5.1352 (3)

VARIABLE ENTERED	REMOVED	MULTIPLE R	RSQ
T326 7		0.4140	0.1714
HUM 5		0.5268	0.2775
WD 2		0.5588	0.3123
PRES 4		0.5830	0.3399
WS 3		0.5907	0.3489

DF	F RATIO	27
5	2.152	
25		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	-9272.17041)		
WD 2	0.35911	0.32272	1.2382 (3)
WS 3	6.99781	8.08827	0.7485 (3)
PRES 4	326.45296	234.18752	1.9432 (3)
HUM 5	-2.37714	2.89987	0.6720 (3)
T327 8	-130.19232	74.36352	3.0651 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4242	0.1800
T327 8		0.4843	0.2345
WD 2		0.5311	0.2821
HUM 5		0.5485	0.3009

DF	F RATIO	28
5	2.157	
25		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	-9260.66760)		
WD 2	0.36745	0.32261	1.2973 (3)
WS 3	6.94603	8.09367	0.7365 (3)
PRES 4	326.21613	234.10291	1.9418 (3)
HUM 5	-2.43632	2.91633	0.6979 (3)
T328 9	-131.57553	74.88831	3.0869 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4242	0.1800
T328 9		0.4828	0.2331
WD 2		0.5309	0.2819
HUM 5		0.5490	0.3014

29

DF	F RATIO
5	2.129
25	

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	-9016.71265)		
WD 2	0.39731	0.32390	1.5046 (3)
WS 3	7.05471	8.11504	0.7557 (3)
PRES 4	317.04607	235.21345	1.8169 (3)
HUM 5	-2.29710	2.89038	0.6316 (3)
T329 10	-120.73350	69.97517	2.9769 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4242	0.1800
T329 10		0.4778	0.2283
WD 2		0.5300	0.2809
HUM 5		0.5465	0.2987

30

DF	F RATIO
5	2.081
25	

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	-9203.87341)		
WD 2	0.40520	0.32540	1.5506 (3)
WS 3	7.40547	8.10165	0.8355 (3)
PRES 4	322.68541	235.71748	1.8740 (3)
HUM 5	-2.17013	2.88669	0.5652 (3)
T330 11	-118.45199	70.95879	2.7866 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4242	0.1800
T330 11		0.4739	0.2246
WD 2		0.5271	0.2779
HUM 5		0.5421	0.2938

DF	F RATIO	31
5	2.064	
25		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		-9133.78101)		
WD	2	0.39975	0.32556	1.5077 (3)
WS	3	7.61421	8.06880	0.8905 (3)
PRES	4	320.30370	236.20638	1.8388 (3)
HUM	5	-2.19629	2.91196	0.5689 (3)
T331	6	-117.42099	71.19150	2.7204 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4242	0.1800
T331	6		0.4730	0.2237
WD	2		0.5254	0.2761
HUM	5		0.5405	0.2922

DF	F RATIO	32
5	2.130	
25		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		-8785.51758)		
WD	2	0.39767	0.32390	1.5074 (3)
WS	3	7.30692	8.03435	0.8271 (3)
PRES	4	309.27338	235.81466	1.7201 (3)
HUM	5	-2.32563	2.90027	0.6430 (3)
T332	7	-120.69716	69.93281	2.9787 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4242	0.1800
T332	7		0.4774	0.2279
WD	2		0.5298	0.2807
HUM	5		0.5465	0.2987

DF F RATIO (PS,SS) 33
5 2.885
25

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		-6926.75641)		
WD	2	0.47065	0.31061	2.2960 (3)
WS	3	4.66237	7.65740	0.3707 (3)
PRES	4	251.13825	227.01345	1.2238 (3)
HUM	5	-3.32265	2.73901	1.4716 (3)
T333	8	-152.77494	62.67364	5.9420 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
T333	8		0.3722	0.1385
HUM	5		0.5187	0.2690
WD	2		0.5778	0.3338
PRES	4		0.5970	0.3565
WS	3		0.6049	0.3659

DF F RATIO (PS,SS) 34
5 2.769
25

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		-7074.32367)		
WD	2	0.45163	0.31203	2.0949 (3)
WS	3	5.02737	7.70486	0.4257 (3)
PRES	4	255.35047	228.60174	1.2471 (3)
HUM	5	-3.18218	2.75709	1.3321 (3)
T334	9	-144.71181	61.78270	5.4862 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
T334	9		0.3681	0.1355
HUM	5		0.5126	0.2628
WD	2		0.5682	0.3228
PRES	4		0.5877	0.3454
WS	3		0.5970	0.3564

DF F RATIO (PS,SS) 35
5 2.985
25

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	-5186.03345)		
WD 2	0.37288	0.30546	1.4902 (3)
WS 3	2.93139	7.94083	0.1363 (3)
PRES 4	194.78881	230.99890	0.7111 (3)
HUM 5	-3.51490	2.74283	1.6422 (3)
T335 10	-164.05202	65.18371	6.3341 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T335 10		0.4319	0.1865
HUM 5		0.5638	0.3178
WD 2		0.5966	0.3560
PRES 4		0.6086	0.3704
WS 3		0.6114	0.3738

DF F RATIO (PS,SS) 36
5 2.829
25

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	-5362.27240)		
WD 2	0.36456	0.30844	1.3970 (3)
WS 3	3.41803	8.01591	0.1818 (3)
PRES 4	199.46091	233.56082	0.7293 (3)
HUM 5	-3.23179	2.74118	1.3900 (3)
T336 11	-154.44959	64.55168	5.7248 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T336 11		0.4285	0.1836
HUM 5		0.5533	0.3061
WD 2		0.5854	0.3426
PRES 4		0.5973	0.3567
WS 3		0.6011	0.3614

DF	F RATIO
5	1.825
25	

37

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		10110.89648)		
WD	2	0.40571	0.34013	1.4228 (3)
WS	3	9.45425	8.32668	1.2892 (3)
PRES	4	349.06415	241.93596	2.0817 (3)
HUM	5	-1.27043	2.98941	0.1806 (3)
T337	6	-87.30335	81.47028	1.1483 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4534	0.2056
WD	2		0.4800	0.2304
T337	6		0.5119	0.2621
HUM	5		0.5171	0.2674

DF	F RATIO
5	1.855
25	

38

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		-9530.49487)		
WD	2	0.42016	0.34162	1.5126 (3)
WS	3	8.95794	8.43986	1.1265 (3)
PRES	4	330.22354	245.07655	1.8156 (3)
HUM	5	-1.36028	2.97883	0.2085 (3)
T338	7	-91.85213	81.66284	1.2651 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4534	0.2056
WD	2		0.4800	0.2304
T338	7		0.5143	0.2646
HUM	5		0.5202	0.2706

DF	F RATIO	39
5	1.805	
25		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		-9358.50806)		
WD	2	0.40705	0.34152	1.4205 (3)
WS	3	9.24459	8.55286	1.1683 (3)
PRES	4	324.04794	249.58388	1.6857 (3)
HUM	5	-1.28044	3.04106	0.1773 (3)
T339	8	-87.93041	84.90698	1.0725 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4534	0.2056
WD	2		0.4800	0.2304
T339	8		0.5099	0.2600
HUM	5		0.5150	0.2652

DF	F RATIO	40
5	1.851	
25		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		-9418.10767)		
WD	2	0.42210	0.34229	1.5207 (3)
WS	3	8.96285	8.45646	1.1234 (3)
PRES	4	326.42002	246.25687	1.7570 (3)
HUM	5	-1.33196	2.97037	0.2011 (3)
T340	9	-91.65600	81.97088	1.2503 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4534	0.2056
WD	2		0.4800	0.2304
T340	9		0.5142	0.2644
HUM	5		0.5198	0.2702

41

DF	F RATIO
5	1.714
25	

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	10221.96338)		
WD 2	0.40710	0.34831	1.3660 (3)
WS 3	10.17406	8.60871	1.3967 (3)
PRES 4	350.67531	247.01758	2.0154 (3)
HUM 5	-0.85702	3.01035	0.0810 (3)
T341 10	-71.08031	83.55979	0.7236 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4534	0.2056
WD 2		0.4800	0.2304
T341 10		0.5029	0.2529
HUM 5		0.5053	0.2553

42

DF	F RATIO
5	1.671
25	

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	10148.68079)		
WD 2	0.39757	0.34954	1.2937 (3)
WS 3	10.82916	8.52613	1.6132 (3)
PRES 4	346.94997	252.06776	1.8945 (3)
HUM 5	-0.64183	2.99931	0.0458 (3)
T342 11	-61.17206	81.68842	0.5608 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4534	0.2056
WD 2		0.4800	0.2304
T342 11		0.4992	0.2492
HUM 5		0.5005	0.2505

DF	F RATIO
5	1.664
25	

43

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		10154.74292)		
WD	2	0.39809	0.35065	1.2889 (3)
WS	3	10.93991	8.51525	1.6506 (3)
PRES	4	346.89722	252.91247	1.8813 (3)
HUM	5	-0.59471	2.98999	0.0396 (3)
T343	6	-59.82579	81.92356	0.5333 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4534	0.2056
WD	2		0.4800	0.2304
T343	6		0.4985	0.2485
HUM	5		0.4997	0.2497

DF	F RATIO
5	1.629
25	

44

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		10406.23621)		
WD	2	0.38598	0.35063	1.2118 (3)
WS	3	11.29540	8.66348	1.6999 (3)
PRES	4	354.60892	253.88762	1.9508 (3)
HUM	5	-0.46650	3.05305	0.0233 (3)
T344	7	-53.95984	85.49606	0.3983 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4534	0.2056
WD	2		0.4800	0.2304
T344	7		0.4950	0.2450
HUM	5		0.4957	0.2457

45

DF	F RATIO
5	1.657
25	

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	10275.92761)		
WD 2	0.39732	0.35137	1.2787 (3)
WS 3	10.94509	8.59772	1.6206 (3)
PRES 4	351.00084	251.92172	1.9413 (3)
HUM 5	-0.59647	3.02600	0.0389 (3)
T345 8	-61.16173	86.10862	0.5045 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4534	0.2056
WD 2		0.4800	0.2304
T345 8		0.4977	0.2477
HUM 5		0.4989	0.2489

46

DF	F RATIO
5	1.646
25	

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	10324.96667)		
WD 2	0.38744	0.34876	1.2342 (3)
WS 3	11.11930	8.57916	1.6798 (3)
PRES 4	352.26337	252.61868	1.9445 (3)
HUM 5	-0.51615	3.00438	0.0295 (3)
T346 9	-57.70427	84.67111	0.4645 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4534	0.2056
WD 2		0.4800	0.2304
T346 9		0.4968	0.2468
HUM 5		0.4977	0.2477

DF	F RATIO	
5	1.672	47
25		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	10170.16370)		
WD 2	0.39878	0.34996	1.2985 (3)
WS 3	10.50688	8.78262	1.4312 (3)
PRES 4	347.82140	251.64732	1.9104 (3)
HUM 5	-0.63081	2.98846	0.0446 (3)
T347 10	-64.04284	85.41138	0.5622 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4534	0.2056
WD 2		0.4800	0.2304
T347 10		0.4992	0.2492
HUM 5		0.5006	0.2506

DF	F RATIO	
5	1.736	48
25		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	-9584.48743)		
WD 2	0.42338	0.35160	1.4500 (3)
WS 3	9.64761	8.78457	1.2061 (3)
PRES 4	329.98383	252.65937	1.7057 (3)
HUM 5	-0.93977	2.99904	0.0982 (3)
T348 11	-79.36220	88.19145	0.8098 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4534	0.2056
WD 2		0.4800	0.2304
T348 11		0.5048	0.2549
HUM 5		0.5077	0.2578

49

DF	F RATIO
5	1.785
25	

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		-8975.05664)		
WD	2	0.43416	0.35038	1.5354 (3)
WS	3	9.05090	8.79933	1.0580 (3)
PRES	4	310.60344	255.79864	1.4744 (3)
HUM	5	-1.11889	2.96691	0.1403 (3)
T349	6	-87.89530	88.02591	0.9970 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4534	0.2056
WD	2		0.4800	0.2304
T349	6		0.5089	0.2590
HUM	5		0.5129	0.2631

50

DF	F RATIO
5	1.818
25	

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		-8865.95020)		
WD	2	0.44347	0.35036	1.6021 (3)
WS	3	8.78679	8.73995	1.0107 (3)
PRES	4	307.73227	254.12073	1.4664 (3)
HUM	5	-1.30165	3.02248	0.1855 (3)
T350	7	-93.59868	88.28971	1.1239 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4534	0.2056
WD	2		0.4800	0.2304
T350	7		0.5111	0.2613
HUM	5		0.5164	0.2667

DF	F RATIO
5	1.786
25	

51

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	-9002.40344)		
WD 2	0.43133	0.34944	1.5236 (3)
WS 3	9.06044	8.78930	1.0626 (3)
PRES 4	312.05768	255.19252	1.4953 (3)
HUM 5	-1.29969	3.10352	0.1754 (3)
T351 8	-89.73219	89.76843	0.9992 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4534	0.2056
WD 2		0.4800	0.2304
T351 8		0.5079	0.2580
HUM 5		0.5130	0.2632

DF	F RATIO
5	1.752
25	

52

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	-9030.66638)		
WD 2	0.42820	0.35165	1.4828 (3)
WS 3	9.23285	8.93940	1.0667 (3)
PRES 4	312.47562	258.29160	1.4636 (3)
HUM 5	-1.19923	3.13607	0.1462 (3)
T352 9	-85.25391	91.44084	0.8693 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4534	0.2056
WD 2		0.4800	0.2304
T352 9		0.5051	0.2551
HUM 5		0.5094	0.2595

DF	F RATIO
5	1.756
25	

53

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	-9040.64795)		
WD 2	0.42804	0.35120	1.4855 (3)
WS 3	9.25662	8.89083	1.0840 (3)
PRES 4	312.94828	257.68509	1.4749 (3)
HUM 5	-1.22094	3.13922	0.1513 (3)
T353 10	-86.61677	92.12625	0.8840 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4534	0.2056
WD 2		0.4800	0.2304
T353 10		0.5054	0.2554
HUM 5		0.5098	0.2599

DF	F RATIO
5	1.718
25	

54

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	-9478.40125)		
WD 2	0.41458	0.35051	1.3990 (3)
WS 3	9.95214	8.73453	1.2982 (3)
PRES 4	326.22462	256.06399	1.6231 (3)
HUM 5	-0.94224	3.06192	0.0947 (3)
T354 11	-76.52773	89.09350	0.7378 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4534	0.2056
WD 2		0.4800	0.2304
T354 11		0.5029	0.2529
HUM 5		0.5057	0.2557

55

DF	F RATIO
5	1.696
25	

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		-9488.70447)		
WD	2	0.41396	0.35282	1.3766 (3)
WS	3	10.07978	8.85192	1.2967 (3)
PRES	4	316.20931	258.70080	1.5900 (3)
HUM	5	-0.87855	3.09359	0.0807 (3)
T355	6	-74.26577	91.75977	0.6550 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4534	0.2056
WD	2		0.4800	0.2304
T355	6		0.5009	0.2509
HUM	5		0.5033	0.2533

56

DF	F RATIO
5	1.682
25	

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		-9508.84473)		
WD	2	0.40821	0.35242	1.3416 (3)
WS	3	10.35983	8.78934	1.3893 (3)
PRES	4	326.41705	260.66745	1.5679 (3)
HUM	5	-0.81001	3.09808	0.0684 (3)
T356	7	-70.43656	90.96487	0.5996 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4534	0.2056
WD	2		0.4800	0.2304
T356	7		0.4996	0.2496
HUM	5		0.5017	0.2517

57

DF	F RATIO
5	1.624
25	

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		10158.52588)		
WD	2	0.40319	0.36066	1.2497 (3)
WS	3	10.99891	9.05258	1.4762 (3)
PRES	4	346.39918	259.67389	1.7795 (3)
HUM	5	-0.45419	3.07396	0.0218 (3)
T357	8	-56.63714	92.07285	0.3784 (3)

VARIABLE ENTERED		REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4534	0.2056
WD	2		0.4800	0.2304
T357	8		0.4945	0.2445
HUM	5		0.4951	0.2452

58

DF	F RATIO
5	1.562
25	

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		11170.48682)		
WD	2	0.37649	0.36652	1.0551 (3)
WS	3	12.64590	8.66255	2.1311 (3)
PRES	4	376.95922	254.63775	2.1915 (3)
HUM	5	0.16590	2.85033	0.0034 (3)
T358	9	-30.69139	81.48115	0.1419 (3)

VARIABLE ENTERED		REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4534	0.2056
WD	2		0.4800	0.2304
T358	9		0.4878	0.2380
HUM	5		0.4879	0.2381

DF F RATIO 59
5 1.559
25

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	11175.58838)		
WD 2	0.37444	0.36666	1.0429 (3)
WS 3	12.71815	8.67160	2.1510 (3)
PRES 4	377.01344	255.81788	2.1720 (3)
HUM 5	0.18410	2.85994	0.0041 (3)
T359 10	-29.66450	81.98505	0.1309 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4534	0.2056
WD 2		0.4800	0.2304
T359 10		0.4874	0.2376
HUM 5		0.4876	0.2377

DF F RATIO 60
5 1.581
25

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	10871.78870)		
WD 2	0.38838	0.36580	1.1273 (3)
WS 3	12.11540	8.76554	1.9104 (3)
PRES 4	367.75674	255.71781	2.0682 (3)
HUM 5	0.03433	2.83824	0.0001 (3)
T360 11	-37.09714	80.19133	0.2140 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4534	0.2056
WD 2		0.4800	0.2304
T360 11		0.4901	0.2402
HUM 5		0.4901	0.2402

DF	F RATIO
5	1.599
25	

61

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		10560.26196)		
WD	2	0.39876	0.36583	1.1882 (3)
WS	3	11.77310	8.72542	1.8206 (3)
PRES	4	357.93980	257.90084	1.9263 (3)
HUM	5	-0.05460	2.81272	0.0004 (3)
T361	6	-43.37643	81.59054	0.2826 (3)

VARIABLE ENTERED		REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4534	0.2056
WD	2		0.4800	0.2304
T361	6		0.4922	0.2423
HUM	5		0.4922	0.2423

DF	F RATIO
5	1.606
25	

62

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		10464.46655)		
WD	2	0.40489	0.36746	1.2141 (3)
WS	3	11.71768	8.63733	1.8405 (3)
PRES	4	354.92918	258.18075	1.8899 (3)
HUM	5	-0.10807	2.82587	0.0015 (3)
T362	7	-45.23054	81.23239	0.3100 (3)

VARIABLE ENTERED		REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4534	0.2056
WD	2		0.4800	0.2304
T362	7		0.4930	0.2431
HUM	5		0.4931	0.2431

DF	F RATIO
5	1.610
25	

63

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		10395.83508)		
WD	2	0.40660	0.36704	1.2272 (3)
WS	3	11.64967	8.62709	1.8235 (3)
PRES	4	352.80016	258.57347	1.8616 (3)
HUM	5	-0.15385	2.84750	0.0029 (3)
T363	8	-46.05396	80.58486	0.3266 (3)

VARIABLE ENTERED		REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4534	0.2056
WD	2		0.4800	0.2304
T363	8		0.4935	0.2435
HUM	5		0.4935	0.2436

DF	F RATIO
5	1.604
25	

64

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		10335.98975)		
WD	2	0.40275	0.36673	1.2061 (3)
WS	3	11.71504	8.68205	1.8207 (3)
PRES	4	350.73155	261.69496	1.7962 (3)
HUM	5	-0.15109	2.88304	0.0027 (3)
T364	9	-45.20994	82.26275	0.3020 (3)

VARIABLE ENTERED		REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4534	0.2056
WD	2		0.4800	0.2304
T364	9		0.4927	0.2428
HUM	5		0.4928	0.2429

DF	F RATIO
5	1.645
25	

65

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	-9817.12781)		
WD 2	0.42578	0.36837	1.3360 (3)
WS 3	11.11652	8.59738	1.6719 (3)
PRES 4	334.45501	262.64554	1.6214 (3)
HUM 5	-0.33441	2.84850	0.0138 (3)
T365 10	-55.38683	81.67797	0.4598 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4534	0.2056
WD 2		0.4800	0.2304
T365 10		0.4971	0.2472
HUM 5		0.4976	0.2476

DF	F RATIO
5	1.641
25	

66

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	-9963.80078)		
WD 2	0.42658	0.37005	1.3289 (3)
WS 3	11.16309	8.61008	1.6809 (3)
PRES 4	335.86055	262.60688	1.6357 (3)
HUM 5	-0.30384	2.83893	0.0115 (3)
T366 11	-54.54125	81.81361	0.4444 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4534	0.2056
WD 2		0.4800	0.2304
T366 11		0.4968	0.2468
HUM 5		0.4971	0.2471

67

DF	F RATIO
5	1.595
25	

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		10382.64392)		
WD	2	0.40156	0.36979	1.1792 (3)
WS	3	11.92450	8.64502	1.9026 (3)
PRES	4	351.92786	263.69996	1.7811 (3)
HUM	5	-0.08405	2.87195	0.0009 (3)
T367	6	-43.12258	83.51263	0.2666 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4534	0.2056
WD	2		0.4800	0.2304
T367	6		0.4917	0.2418
HUM	5		0.4917	0.2418

68

DF	F RATIO
5	1.624
25	

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		-9943.36072)		
WD	2	0.41958	0.37100	1.2791 (3)
WS	3	11.42286	8.61671	1.7574 (3)
PRES	4	338.20259	265.07110	1.6279 (3)
HUM	5	-0.26230	2.87880	0.0083 (3)
T368	7	-52.35504	84.94462	0.3799 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
WS	3		0.3260	0.1063
PRES	4		0.4534	0.2056
WD	2		0.4800	0.2304
T368	7		0.4949	0.2449
HUM	5		0.4952	0.2452

DF | F RATIO | 69
5 | 1.662
25

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	-9532.44763)		
WD 2	0.42813	0.36544	1.3725 (3)
WS 3	10.92855	8.55277	1.6327 (3)
PRES 4	327.03312	263.78175	1.5371 (3)
HUM 5	-0.41506	2.85100	0.0212 (3)
T369 8	-60.35477	83.40685	0.5236 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4534	0.2056
WD 2		0.4800	0.2304
T369 8		0.4988	0.2488
HUM 5		0.4994	0.2494

DF | F RATIO | 70
5 | 1.724
25

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	-9197.02429)		
WD 2	0.44838	0.36333	1.5229 (3)
WS 3	10.12663	8.55675	1.4006 (3)
PRES 4	315.50148	260.18251	1.4704 (3)
HUM 5	-0.63358	2.82404	0.0503 (3)
T370 9	-72.98417	83.59055	0.7623 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4534	0.2056
WD 2		0.4800	0.2304
T370 9		0.5049	0.2549
HUM 5		0.5064	0.2564

DF F RATIO 71
5 1.750
25

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	-8890.67969)		
WD 2	0.45275	0.36129	1.5704 (3)
WS 3	9.68379	8.65318	1.2524 (3)
PRES 4	305.98003	261.43475	1.3698 (3)
HUM 5	-0.75707	2.84251	0.0709 (3)
T371 10	-78.65624	84.79306	0.8605 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4534	0.2056
WD 2		0.4800	0.2304
T371 10		0.5071	0.2571
HUM 5		0.5091	0.2592

DF F RATIO 72
5 1.759
25

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	-8906.60950)		
WD 2	0.45046	0.35909	1.5737 (3)
WS 3	9.55369	8.66878	1.2146 (3)
PRES 4	306.79160	259.99551	1.3924 (3)
HUM 5	-0.82185	2.86194	0.0825 (3)
T372 11	-79.76182	84.26525	0.8960 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
WS 3		0.3260	0.1063
PRES 4		0.4534	0.2056
WD 2		0.4800	0.2304
T372 11		0.5077	0.2578
HUM 5		0.5101	0.2602

APPENDIX C

FAILURE GROUP THREE (PIGA FAILURES) VERSUS ENVIRONMENTAL GROUPS A, B, AND C

This appendix is divided into three sub-appendices. Appendices C-1, C-2, and C-3 contain respectively the equations that resulted from regressing TBSF of PIGA failures against environmental groups A, B, and C. The appropriate F-distribution values for the appendix are listed in Figure 29 on page 99.

Preceding page blank

APPENDIX C-1

FAILURE GROUP THREE (PIGA FAILURES)

VERSUS ENVIRONMENTAL GROUP A

DF	F RATIO
5	0.724
71	

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	1054.85475)		
TEMP 2	-0.78608	0.70918	1.2286 (3)
WD 3	0.00164	0.11911	0.0002 (3)
WS 4	0.00924	2.64379	0.0000 (3)
PRES 5	-32.06063	67.97281	0.2225 (3)
HUM 6	0.85904	0.80180	1.1479 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
HUM 6		0.1776	0.0315
TEMP 2		0.2129	0.0453
PRES 5		0.2203	0.0485
WD 3		0.2203	0.0485
WS 4		0.2203	0.0485

APPENDIX C-2

FAILURE GROUP THREE (PIGA FAILURES)

VERSUS ENVIRONMENTAL GROUP B

DF F RATIO 1
5 1.265
71

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		2739.04254)		
WD	2	-0.01983	0.11731	0.0286 (3)
WS	3	-0.19301	2.60511	0.0055 (3)
PRES	4	-87.01939	65.19552	1.7815 (3)
HUM	5	0.68458	0.77671	0.7768 (3)
T26	6	-1.25755	0.67456	3.4754 (3)

VARIABLE ENTERED		REMOVED	MULTIPLE R	RSQ
T26	6		0.1898	0.0360
PRES	4		0.2650	0.0702
HUM	5		0.2852	0.0814
WD	2		0.2859	0.0817
WS	3		0.2860	0.0818

DF F RATIO 2
5 1.492
71

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		2909.08582)		
WD	2	-0.01157	0.11559	0.0100 (3)
WS	3	-0.17431	2.58482	0.0045 (3)
PRES	4	-92.75801	64.46670	2.0703 (3)
HUM	5	0.83166	0.75464	1.2146 (3)
T212	7	-1.45254	0.67963	4.5679 (3)

VARIABLE ENTERED		REMOVED	MULTIPLE R	RSQ
T212	7		0.1999	0.0400
PRES	4		0.2795	0.0781
HUM	5		0.3080	0.0949
WD	2		0.3082	0.0950
WS	3		0.3083	0.0951

DF	F RATIO
5	1.413
71	

3

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		2824.02975)		
WD	2	-0.00340	0.11554	0.0009 (3)
WS	3	-0.29910	2.58784	0.0134 (3)
PRES	4	-90.08183	64.54742	1.9477 (3)
HUM	5	0.88233	0.75427	1.3684 (3)
T218	8	-1.44492	0.70599	4.1889 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
T218	8		0.1872	0.0350
PRES	4		0.2667	0.0711
HUM	5		0.3005	0.0903
WS	3		0.3008	0.0905
WD	2		0.3008	0.0905

DF	F RATIO
5	1.238
71	

4

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		2620.05472)		
WD	2	-0.00513	0.11638	0.0019 (3)
WS	3	-0.37704	2.60116	0.0210 (3)
PRES	4	-83.41908	64.65270	1.6648 (3)
HUM	5	0.87137	0.76001	1.3145 (3)
T224	9	-1.32370	0.72383	3.3443 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
HUM	5		0.1776	0.0315
T224	9		0.2412	0.0582
PRES	4		0.2826	0.0799
WS	3		0.2831	0.0801
WD	2		0.2831	0.0802

5

DF	F RATIO
5	1.269
71	

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	2610.55334)		
WD 2	-0.00613	0.11629	0.0028 (3)
WS 3	-0.35825	2.59886	0.0190 (3)
PRES 4	-83.04681	64.29249	1.6685 (3)
HUM 5	0.86639	0.75933	1.3019 (3)
T230 10	-1.35017	0.72210	3.4961 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
HUM 5		0.1776	0.0315
T230 10		0.2450	0.0600
PRES 4		0.2860	0.0818
WS 3		0.2864	0.0820
WD 2		0.2864	0.0820

6

DF	F RATIO
5	1.295
71	

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	2599.24710)		
WD 2	-0.00341	0.11604	0.0009 (3)
WS 3	-0.36288	2.59649	0.0195 (3)
PRES 4	-82.74196	64.01663	1.6706 (3)
HUM 5	0.90486	0.75653	1.4306 (3)
T236 11	-1.36802	0.71903	3.6199 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
HUM 5		0.1776	0.0315
T236 11		0.2480	0.0615
PRES 4		0.2886	0.0833
WS 3		0.2891	0.0836
WD 2		0.2891	0.0836

DF	F RATIO	7
5	1.254	
71		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		2558.16379)		
WD	2	0.00072	0.11603	0.0000 (3)
WS	3	-0.44689	2.59832	0.0296 (3)
PRES	4	-81.45021	64.09270	1.6150 (3)
HUM	5	0.91565	0.75721	1.4623 (3)
T242	6	-1.34230	0.72578	3.4205 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
HUM	5		0.1776	0.0315
T242	6		0.2444	0.0598
PRES	4		0.2841	0.0807
WS	3		0.2848	0.0811
WD	2		0.2848	0.0811

DF	F RATIO	8
5	1.196	
71		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		2460.44983)		
WD	2	0.00123	0.11625	0.0001 (3)
WS	3	-0.46500	2.60292	0.0319 (3)
PRES	4	-78.24568	63.90881	1.4990 (3)
HUM	5	0.90103	0.75955	1.4072 (3)
T248	7	-1.28740	0.72588	3.1455 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
HUM	5		0.1776	0.0315
T248	7		0.2405	0.0578
PRES	4		0.2780	0.0773
WS	3		0.2788	0.0777
WD	2		0.2788	0.0777

DF	F RATIO	9
5	1.241	
71		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	2501.35641)		
WD 2	0.00165	0.11605	0.0002 (3)
WS 3	-0.46302	2.59911	0.0317 (3)
PRES 4	-79.52203	63.79876	1.5536 (3)
HUM 5	0.88447	0.75913	1.3575 (3)
T254 8	-1.32550	0.72300	3.3611 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
HUM 5		0.1776	0.0315
T254 8		0.2446	0.0598
PRES 4		0.2828	0.0800
WS 3		0.2835	0.0804
WD 2		0.2835	0.0804

DF	F RATIO	10
5	1.283	
71		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	2517.20111)		
WD 2	0.00248	0.11585	0.0005 (3)
WS 3	-0.47651	2.59536	0.0337 (3)
PRES 4	-80.04234	63.57387	1.5852 (3)
HUM 5	0.90365	0.75692	1.4253 (3)
T260 9	-1.35605	0.71842	3.5628 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T260 9		0.1785	0.0319
HUM 5		0.2489	0.0619
PRES 4		0.2871	0.0824
WS 3		0.2879	0.0829
WD 2		0.2879	0.0829

DF	F RATIO	11
5	1.280	
71		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	2514.02057)		
WD 2	0.00392	0.11581	0.0011 (3)
WS 3	-0.51284	2.59525	0.0390 (3)
PRES 4	-79.93315	63.57885	1.5806 (3)
HUM 5	0.90083	0.75715	1.4155 (3)
T266 10	-1.35421	0.71913	3.5462 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T266 10		0.1782	0.0318
HUM 5		0.2485	0.0618
PRES 4		0.2866	0.0821
WS 3		0.2875	0.0826
WD 2		0.2875	0.0827

DF	F RATIO	12
5	1.218	
71		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	2456.60211)		
WD 2	0.00483	0.11603	0.0017 (3)
WS 3	-0.54417	2.60022	0.0438 (3)
PRES 4	-78.06499	63.69222	1.5022 (3)
HUM 5	0.88875	0.75959	1.3690 (3)
T272 11	-1.30615	0.72466	3.2487 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
HUM 5		0.1776	0.0315
T272 11		0.2430	0.0591
PRES 4		0.2800	0.0784
WS 3		0.2810	0.0790
WD 2		0.2811	0.0790

APPENDIX C-3

FAILURE GROUP THREE (PIGA FAILURES)

VERSUS ENVIRONMENTAL GROUP C

DF	F RATIO
5	0.544
71	

1

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	1133.44734)		
WD 2	0.01618	0.11900	0.0185 (3)
WS 3	-0.60320	2.66370	0.0513 (3)
PRES 4	-36.26862	61.03413	0.3531 (3)
HUM 5	1.02284	0.78509	1.6974 (3)
T31 6	-0.31050	7.43099	0.0017 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
HUM 5		0.1776	0.0315
PRES 4		0.1894	0.0359
WS 3		0.1913	0.0366
WD 2		0.1920	0.0368
T31 6		0.1920	0.0369

DF	F RATIO
5	0.896
71	

2

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	1758.50124)		
WD 2	0.00361	0.11750	0.0009 (3)
WS 3	-0.98981	2.64494	0.1400 (3)
PRES 4	-55.54537	61.74038	0.8094 (3)
HUM 5	0.70618	0.80274	0.7739 (3)
T32 7	-12.41461	9.52821	1.6976 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
HUM 5		0.1776	0.0315
T32 7		0.2196	0.0482
PRES 4		0.2397	0.0575
WS 3		0.2436	0.0593
WD 2		0.2436	0.0593

DF	F RATIO	3
5	0.942	
71		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	1707.51265)		
WD 2	-0.00393	0.11784	0.0011 (3)
WS 3	-0.95906	2.63671	0.1323 (3)
PRES 4	-53.56109	61.12783	0.7678 (3)
HUM 5	0.65966	0.80768	0.6671 (3)
T33 8	-15.18723	10.96601	1.9180 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T33 8		0.1870	0.0350
HUM 5		0.2276	0.0518
PRES 4		0.2458	0.0604
WS 3		0.2493	0.0622
WD 2		0.2494	0.0622

DF	F RATIO	4
5	1.489	
71		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	1829.22655)		
WD 2	-0.00024	0.11511	0.0000 (3)
WS 3	-0.94825	2.58273	0.1348 (3)
PRES 4	-56.46777	59.51976	0.9001 (3)
HUM 5	0.36740	0.81058	0.2054 (3)
T34 9	-24.39908	11.43076	4.5561 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T34 9		0.2758	0.0761
PRES 4		0.2989	0.0893
HUM 5		0.3053	0.0932
WS 3		0.3081	0.0949
WD 2		0.3081	0.0949

DF	F RATIO	
5	1.304	5
71		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	1722.78915)		
WD 2	0.01418	0.11553	0.0151 (3)
WS 3	-0.83202	2.59577	0.1027 (3)
PRES 4	-53.30288	59.78079	0.7950 (3)
HUM 5	0.47257	0.80761	0.3424 (3)
T35 10	-23.08766	12.06475	3.6620 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T35 10		0.2525	0.0637
PRES 4		0.2771	0.0768
HUM 5		0.2873	0.0826
WS 3		0.2896	0.0839
WD 2		0.2900	0.0841

DF	F RATIO	
5	1.214	6
71		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	1680.98135)		
WD 2	0.02077	0.11588	0.0321 (3)
WS 3	-0.62404	2.60046	0.0576 (3)
PRES 4	-51.80682	59.91484	0.7477 (3)
HUM 5	0.36857	0.84027	0.1924 (3)
T36 11	-23.42303	13.03604	3.2285 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T36 11		0.2492	0.0621
PRES 4		0.2728	0.0744
HUM 5		0.2785	0.0776
WS 3		0.2799	0.0783
WD 2		0.2806	0.0787

7

DF	F RATIO
5	1.278
71	

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		1564.63295)		
WD	2	0.03164	0.11589	0.0745 (3)
WS	3	-0.62801	2.59502	0.0586 (3)
PRES	4	-47.67544	59.46504	0.6428 (3)
HUM	5	0.26846	0.85554	0.0985 (3)
T37	6	-25.41512	13.50745	3.5403 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
T37	6		0.2630	0.0692
PRES	4		0.2812	0.0791
HUM	5		0.2843	0.0808
WD	2		0.2861	0.0818
WS	3		0.2874	0.0826

8

DF	F RATIO
5	1.222
71	

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		1552.88611)		
WD	2	0.03047	0.11608	0.0689 (3)
WS	3	-0.69059	2.60021	0.0705 (3)
PRES	4	-46.94122	59.55610	0.6212 (3)
HUM	5	0.20177	0.88311	0.0522 (3)
T38	7	-27.40142	15.15314	3.2699 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
T38	7		0.2593	0.0673
PRES	4		0.2763	0.0763
WS	3		0.2787	0.0777
WD	2		0.2803	0.0786
HUM	5		0.2815	0.0793

DF	F RATIO	9
5	1.740	
71		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		1645.36797)		
WD	2	0.03138	0.11410	0.0756 (3)
WS	3	-0.98003	2.56212	0.1463 (3)
PRES	4	-50.08212	58.57197	0.7311 (3)
HUM	5	-0.11328	0.88234	0.0165 (3)
T39	8	-37.64660	15.63229	5.7628 (3)

VARIABLE ENTERED		REMOVED	MULTIPLE R	RSQ
T39	8		0.3132	0.0981
PRES	4		0.3261	0.1063
WS	3		0.3286	0.1080
WD	2		0.3301	0.1089
HUM	5		0.3304	0.1092

DF	F RATIO	10
5	2.299	
71		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		1815.13310)		
WD	2	0.04905	0.11254	0.1900 (3)
WS	3	-0.73598	2.51391	0.0857 (3)
PRES	4	-54.00536	57.61564	0.8786 (3)
HUM	5	-0.23110	0.84927	0.0740 (3)
T310	9	-44.80348	15.40929	8.4539 (3)

VARIABLE ENTERED		REMOVED	MULTIPLE R	RSQ
T310	9		0.3544	0.1256
PRES	4		0.3680	0.1354
WD	2		0.3711	0.1377
WS	3		0.3721	0.1384
HUM	5		0.3733	0.1393

DF	F RATIO	11
5	1.732	
71		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	1615.25581)		
WD 2	0.04881	0.11475	0.1809 (3)
WS 3	-0.17452	2.56306	0.0046 (3)
PRES 4	-48.37769	58.52149	0.6834 (3)
HUM 5	0.04267	0.84994	0.0025 (3)
T311 10	-38.32069	16.01817	5.7232 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T311 10		0.3100	0.0961
PRES 4		0.3260	0.1063
WD 2		0.3295	0.1086
WS 3		0.3296	0.1087
HUM 5		0.3297	0.1087

DF	F RATIO (SS)	12
5	2.724	
71		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	1432.90985)		
WD 2	0.03975	0.11080	0.1287 (3)
WS 3	-0.09058	2.48656	0.0013 (3)
PRES 4	-42.76517	56.59479	0.5710 (3)
HUM 5	-0.12986	0.80493	0.0260 (3)
T312 11	-52.45069	16.18428	10.5031 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T312 11		0.3896	0.1518
PRES 4		0.3989	0.1591
WD 2		0.4008	0.1607
HUM 5		0.4012	0.1610
WS 3		0.4012	0.1610

DF	F RATIO	13
5	1.576	
71		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	1620.57211)		
WD 2	0.02369	0.11457	0.0427 (3)
WS 3	0.09767	2.58912	0.0014 (3)
PRES 4	-48.84676	58.86122	0.6887 (3)
HUM 5	0.19085	0.83609	0.0521 (3)
T313 6	-37.32138	16.73187	4.9754 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T313 6		0.2954	0.0873
PRES 4		0.3142	0.0987
HUM 5		0.3152	0.0994
WD 2		0.3161	0.0999
WS 3		0.3161	0.0999

DF	F RATIO	14
5	1.631	
71		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	1699.06680)		
WD 2	0.01555	0.11433	0.0185 (3)
WS 3	0.05832	2.58181	0.0005 (3)
PRES 4	-51.31786	58.85963	0.7602 (3)
HUM 5	0.18660	0.83151	0.0504 (3)
T314 7	-38.08312	16.63937	5.2383 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T314 7		0.2997	0.0898
PRES 4		0.3197	0.1022
HUM 5		0.3206	0.1028
WD 2		0.3210	0.1030
WS 3		0.3210	0.1030

DF	F RATIO	
5	1.933	15
71		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		1919.25145)		
WD	2	0.01178	0.11326	0.0108 (3)
WS	3	-0.35940	2.54342	0.0200 (3)
PRES	4	-58.04435	58.55134	0.9828 (3)
HUM	5	0.15971	0.81145	0.0387 (3)
T315	8	-45.27481	17.50001	6.6932 (3)

VARIABLE ENTERED		REMOVED	MULTIPLE R	RSQ
T315	8		0.3233	0.1045
PRES	4		0.3447	0.1188
HUM	5		0.3456	0.1194
WS	3		0.3460	0.1197
WD	2		0.3462	0.1198

DF	F RATIO	
5	2.087	16
71		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		1964.83034)		
WD	2	0.02065	0.11272	0.0336 (3)
WS	3	-0.23826	2.53316	0.0088 (3)
PRES	4	-59.67387	58.30429	1.0475 (3)
HUM	5	0.13079	0.80557	0.0264 (3)
T316	9	-43.82656	16.07494	7.4332 (3)

VARIABLE ENTERED		REMOVED	MULTIPLE R	RSQ
T316	9		0.3345	0.1119
PRES	4		0.3567	0.1272
WD	2		0.3572	0.1276
HUM	5		0.3578	0.1280
WS	3		0.3579	0.1281

DF	F RATIO	17
5	2.338	
71		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	1987.40683)		
WD 2	0.01973	0.11186	0.0311 (3)
WS 3	-0.26466	2.51298	0.0111 (3)
PRES 4	-60.26433	57.80609	1.0869 (3)
HUM 5	0.13257	0.79067	0.0281 (3)
T317 10	-46.36037	15.76844	8.6440 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T317 10		0.3534	0.1249
PRES 4		0.3748	0.1404
HUM 5		0.3753	0.1409
WD 2		0.3758	0.1412
WS 3		0.3760	0.1414

DF	F RATIO (SS)	18
5	2.506	
71		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	2194.42236)		
WD 2	0.01353	0.11129	0.0148 (3)
WS 3	-0.29453	2.49973	0.0139 (3)
PRES 4	-67.09804	57.81768	1.3468 (3)
HUM 5	0.13001	0.78253	0.0276 (3)
T318 11	-47.20909	15.35506	9.4525 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T318 11		0.3610	0.1303
PRES 4		0.3863	0.1492
HUM 5		0.3869	0.1497
WD 2		0.3871	0.1498
WS 3		0.3873	0.1500

DF F RATIO (SS) 19
5 2.613
71

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	2314.95639)		
WD 2	0.00129	0.11104	0.0001 (3)
WS 3	-0.34291	2.49114	0.0189 (3)
PRES 4	-70.99449	57.81731	1.5078 (3)
HUM 5	0.12741	0.77786	0.0268 (3)
T319 6	-48.08175	15.22953	9.9675 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T319 6		0.3662	0.1341
PRES 4		0.3934	0.1547
HUM 5		0.3939	0.1552
WS 3		0.3942	0.1554
WD 2		0.3942	0.1554

DF F RATIO (SS) 20
5 2.672
71

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	2104.35968)		
WD 2	0.01236	0.11075	0.0124 (3)
WS 3	-0.55236	2.48550	0.0494 (3)
PRES 4	-64.16117	57.32303	1.2528 (3)
HUM 5	0.21397	0.76580	0.0781 (3)
T320 7	-48.06366	15.00990	10.2536 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T320 7		0.3730	0.1391
PRES 4		0.3954	0.1564
HUM 5		0.3970	0.1576
WS 3		0.3978	0.1582
WD 2		0.3980	0.1584

DF	F RATIO	21
5	2.231	
71		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		2162.46866)		
WD	2	0.01080	0.11224	0.0093 (3)
WS	3	-0.23219	2.52186	0.0085 (3)
PRES	4	-66.47549	58.36760	1.2962 (3)
HUM	5	0.23899	0.78260	0.0933 (3)
T321	8	-44.11151	15.47244	8.1281 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
T321	8		0.3386	0.1147
PRES	4		0.3664	0.1343
HUM	5		0.3682	0.1356
WD	2		0.3683	0.1357
WS	3		0.3685	0.1358

DF	F RATIO	22
5	2.202	
71		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		2098.38150)		
WD	2	0.01258	0.11233	0.0125 (3)
WS	3	-0.09731	2.52794	0.0015 (3)
PRES	4	-64.57113	58.35436	1.2253 (3)
HUM	5	0.30200	0.77640	0.1513 (3)
T322	9	-43.43796	15.36969	7.9875 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
T322	9		0.3356	0.1126
PRES	4		0.3635	0.1321
HUM	5		0.3662	0.1341
WD	2		0.3664	0.1342
WS	3		0.3664	0.1342

DF	F RATIO
5	2.014
71	

23

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	2123.80475)		
WD 2	0.00721	0.11302	0.0041 (3)
WS 3	-0.09194	2.54249	0.0013 (3)
PRES 4	-65.47188	58.83518	1.2383 (3)
HUM 5	0.32757	0.78249	0.1752 (3)
T323 10	-42.85506	16.10206	7.0834 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T323 10		0.3189	0.1017
PRES 4		0.3491	0.1219
HUM 5		0.3524	0.1242
WD 2		0.3524	0.1242
WS 3		0.3524	0.1242

DF	F RATIO
5	1.520
71	

24

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	1872.69897)		
WD 2	-0.00317	0.11509	0.0008 (3)
WS 3	-0.24410	2.58007	0.0090 (3)
PRES 4	-57.64856	59.52780	0.9379 (3)
HUM 5	0.45199	0.79415	0.3239 (3)
T324 11	-35.77776	16.49621	4.7039 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
T324 11		0.2750	0.0756
PRES 4		0.3033	0.0920
HUM 5		0.3108	0.0966
WS 3		0.3109	0.0967
WD 2		0.3110	0.0967

DF	F RATIO	25
5	0.493	
71		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		164.67148)		
WD	2	0.01976	0.11882	0.0277 (3)
WS	3	-0.13335	2.66118	0.0025 (3)
PRES	4	-3.72426	63.37144	0.0035 (3)
HUM	5	1.04906	0.80870	1.6828 (3)
T325	6	-6.10183	18.54740	0.1082 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
HUM	5		0.1776	0.0315
T325	6		0.1819	0.0331
WD	2		0.1830	0.0335
PRES	4		0.1831	0.0335
WS	3		0.1832	0.0336

DF	F RATIO	26
5	0.485	
71		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		133.78300)		
WD	2	0.02026	0.11885	0.0291 (3)
WS	3	-0.14163	2.66152	0.0028 (3)
PRES	4	-2.79898	63.44954	0.0019 (3)
HUM	5	1.06474	0.80859	1.7339 (3)
T326	7	-4.95578	18.55408	0.0713 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
HUM	5		0.1776	0.0315
T326	7		0.1805	0.0326
WD	2		0.1817	0.0330
WS	3		0.1817	0.0330
PRES	4		0.1818	0.0330

27

DF	F RATIO
5	0.490
71	

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		164.28665)		
WD	2	0.01980	0.11886	0.0277 (3)
WS	3	-0.15177	2.66060	0.0033 (3)
PRES	4	-3.73968	63.67872	0.0034 (3)
HUM	5	1.05382	0.80930	1.6955 (3)
T327	8	-5.71453	18.56845	0.0947 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
HUM	5		0.1776	0.0315
T327	8		0.1814	0.0329
WD	2		0.1825	0.0333
PRES	4		0.1825	0.0333
WS	3		0.1827	0.0334

28

DF	F RATIO
5	0.478
71	

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		102.77015)		
WD	2	0.02037	0.11911	0.0292 (3)
WS	3	-0.15709	2.66170	0.0035 (3)
PRES	4	-1.88509	64.03831	0.0009 (3)
HUM	5	1.08083	0.81542	1.7569 (3)
T328	9	-3.52623	18.89105	0.0348 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
HUM	5		0.1776	0.0315
T328	9		0.1791	0.0321
WD	2		0.1803	0.0325
WS	3		0.1804	0.0325
PRES	4		0.1804	0.0326

DF	F RATIO	29
5	0.479	
71		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	111.25024)		
WD 2	0.02045	0.11898	0.0295 (3)
WS 3	-0.15942	2.66161	0.0036 (3)
PRES 4	-2.12857	63.88496	0.0011 (3)
HUM 5	1.07404	0.81802	1.7239 (3)
T329 10	-3.96149	19.24368	0.0424 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
HUM 5		0.1776	0.0315
T329 10		0.1794	0.0322
WD 2		0.1806	0.0326
WS 3		0.1807	0.0326
PRES 4		0.1807	0.0327

DF	F RATIO	30
5	0.502	
71		

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	219.26339)		
WD 2	0.01932	0.11878	0.0265 (3)
WS 3	-0.16738	2.65970	0.0040 (3)
PRES 4	-5.39018	63.85397	0.0071 (3)
HUM 5	1.02055	0.82024	1.5481 (3)
T330 11	-7.40251	19.09813	0.1502 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
HUM 5		0.1776	0.0315
T330 11		0.1833	0.0336
WD 2		0.1844	0.0340
PRES 4		0.1846	0.0341
WS 3		0.1847	0.0341

DF	F RATIO	31
5	0.509	
71		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		246.44584)		
WD	2	0.01884	0.11877	0.0252 (3)
WS	3	-0.17589	2.65924	0.0044 (3)
PRES	4	-6.20837	63.83772	0.0095 (3)
HUM	5	1.00786	0.81976	1.5116 (3)
T331	6	-8.32440	19.20732	0.1878 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
HUM	5		0.1776	0.0315
T331	6		0.1847	0.0341
WD	2		0.1857	0.0345
PRES	4		0.1859	0.0346
WS	3		0.1861	0.0346

DF	F RATIO	32
5	0.525	
71		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		278.28741)		
WD	2	0.01719	0.11886	0.0209 (3)
WS	3	-0.17984	2.65788	0.0046 (3)
PRES	4	-7.13178	63.55908	0.0126 (3)
HUM	5	0.99337	0.81438	1.4879 (3)
T332	7	-9.83559	19.25021	0.2611 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
HUM	5		0.1776	0.0315
T332	7		0.1874	0.0351
WD	2		0.1882	0.0354
PRES	4		0.1886	0.0356
WS	3		0.1887	0.0356

DF	F RATIO	
5	0.554	33
71		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		351.93229)		
WD	2	0.01538	0.11882	0.0168 (3)
WS	3	-0.16685	2.65488	0.0039 (3)
PRES	4	-9.36139	63.55312	0.0217 (3)
HUM	5	0.95995	0.81366	1.3919 (3)
T333	8	-12.29062	19.35848	0.4031 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
HUM	5		0.1776	0.0315
T333	8		0.1923	0.0370
PRES	4		0.1930	0.0373
WD	2		0.1936	0.0375
WS	3		0.1938	0.0375

DF	F RATIO	
5	0.532	34
71		

VARIABLES IN EQUATION

VARIABLE		COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT		286.64770)		
WD	2	0.01674	0.11885	0.0198 (3)
WS	3	-0.16003	2.65677	0.0036 (3)
PRES	4	-7.36361	63.36509	0.0135 (3)
HUM	5	0.98929	0.81091	1.4884 (3)
T334	9	-10.56074	19.32493	0.2986 (3)

VARIABLE ENTERED		VARIABLE REMOVED	MULTIPLE R	RSQ
HUM	5		0.1776	0.0315
T334	9		0.1887	0.0356
WD	2		0.1896	0.0359
PRES	4		0.1900	0.0361
WS	3		0.1901	0.0361

DF	F RATIO
5	0.533
71	

35

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	311.34687)		
WD 2	0.01544	0.11906	0.0168 (3)
WS 3	-0.16146	2.65670	0.0037 (3)
PRES 4	-8.15198	63.71486	0.0164 (3)
HUM 5	0.98412	0.81334	1.4640 (3)
T335 10	-10.88829	19.78335	0.3029 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
HUM 5		0.1776	0.0315
T335 10		0.1889	0.0357
WD 2		0.1896	0.0360
PRES 4		0.1901	0.0361
WS 3		0.1902	0.0362

DF	F RATIO
5	0.546
71	

36

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	334.69469)		
WD 2	0.01519	0.11894	0.0163 (3)
WS 3	-0.11635	2.65632	0.0019 (3)
PRES 4	-8.85839	63.57877	0.0194 (3)
HUM 5	0.97095	0.81235	1.4286 (3)
T336 11	-11.80108	19.52817	0.3652 (3)

VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
HUM 5		0.1776	0.0315
T336 11		0.1910	0.0365
PRES 4		0.1918	0.0368
WD 2		0.1924	0.0370
WS 3		0.1924	0.0370

APPENDIX D

COMPUTER PROGRAMS USED TO CONVERT RAW DATA TO USABLE FORM

APPENDIX D

COMPUTER PROGRAMS USED TO CONVERT RAW DATA INTO USABLE FORM

This appendix is divided into two sub-appendices. Appendices D-1 and D-2 contain respectively computer programs MOD1 and MOD2.

Preceding page blank

APPENDIX D-1

COMPUTER PROGRAM MOD1

```
0010C REFERENCE SECTIONS TITLED"INTERMEDIATE FILE",
0020C "CLSC2", AND "FINAL FILES"
0030C THIS PROGRAM WAS USED TO PROCESS THE RAW
0040C DATA FOR INPUT TO FILES CLSC2 AND TI
0050  DIMENSION A(14),B(3),M(7)
0060  CALL ATTACH (13,"75349/CLSC1;",3,0,,)
0070  CALL ATTACH (14,"75349/CLSC2;",3,0,,)
0080  CALL ATTACH (15,"75349/TI;",3,0,,)
0090  CALL FMEDIA (14,5)
0100  CALL FMEDIA (15,5)
0110C LINES 200 THROUGH 300 READ IN THE RAW DATA
0120C FROM FILE CLSC1 (VARIABLES A(1) THROUGH A(10).
0130C VARIABLE B(2) IS THE RESULT OF CONVERTING
0140C TIME OF WS-20 FAILURE TO "YEAR HOURS".
0150C VARIABLE B(1) IS THE RESULT OF CONVERTING TIME
0160C OF WEATHER OBSERVATION TO "YEAR HOURS".
0170C VARIABLES M(2) THROUGH M(7) REPRESENT TEMP,WD,
0180C WS,PIGA FAILURES,DCU FAILURES AND HUMIDITY
0190C RESPECTIVELY.  VARIABLE B(3) EQUALS PRESSURE.
0200  DO 10 J=1,160
0210  READ(13,141)(A(I),I=1,10)
0220  141 FORMAT(V)
0230  B(2)=(A(1)-1)*24+A(2)
0240  B(1)=(A(1)-1)*24+A(3)
0250  M(2)=A(4)
0260  M(3)=A(6)
0270  M(4)=A(7)
0280  B(3)=A(8)
0290  M(5)=A(9)
0300  M(6)=A(10)
0310C LINES 330 THROUGH 380 WERE USED TO CONVERT
0320C DEWPOINT TO HUMIDTIY
0330  C=(A(4)-32)*5./9.
0340  D=(A(5)-32)*5./9.
0350  E=C-D
0360  PRINT 11,C,E
0370  11 FORMAT(F7.2,2X,F7.2)
0380  READ,M(7)
0390  IF(B(2).LE.32.9) GO TO 5
0400C LINE 420 WAS USED TO COMPUTE TIME BETWEEN
0410C SUCCESSIVE FAILURES
0420  B(1)=B(2)-TF
0430C LINES 440 THROUGH 460 WROTE THE DATA INTO FILE TI
0440  WRITE(15,103)B(1),(M(K),K=2,4),B(3),M(7),M(5),M(6)
0450  103 FORMAT(F7.2,2X,I4,2X,I3,2X,I2,2X,
0460  &F5.2,2X,I2,2X,I1,2X,I1)
0470C LINES 480 THROUGH 500 WROTE THE DATA INTO FILE CLSC2
0480  WRITE(14,102)B(1),B(2),(M(K),K=1,4),B(3),M(7),M(5),M(6)
0490  102 FORMAT(F7.2,2X,F7.2,2X,I4,2X,I4,2X,I3,2X,
0500  &I2,2X,F5.2,2X,I2,2X,I1,2X,I1)
0510  5 TF=B(2)
0520  10 CONTINUE
0530  STOP
```

APPENDIX D-2

COMPUTER PROGRAM MOD2

```
0010C REFERENCE SECTION TITLED "FINAL FILES".
0020C THIS PROGRAM WAS USED TO CREATE FINAL FILES
0030C T2A,T2B,T2PA,T2PB,T2DA,T2DB,T3A,T3B,T3PA,T3PB,
0040C T3DA,T3DB,T1P,AND T1D.
0050C INTERMEDIATE FILES CLSC2 AND TEMP
0060C WERE SOURCES OF DATA.
0070  DIMENSION A(3),C(10),D(17),E(12),F(12),G(12),T(8760)
0080  INTEGER WY,WZ
0090  CALL ATTACH (11,"75349/TEMP$",3,0,,)
0100  CALL ATTACH (12,"75349/CLSC2$",3,0,,)
0110  CALL ATTACH (13,"75349/T2A$",3,0,,)
0120  CALL ATTACH (14,"75349/T2B$",3,0,,)
0130  CALL ATTACH (15,"75349/T2PA$",3,0,,)
0140  CALL ATTACH (16,"75349/T2PB$",3,0,,)
0150  CALL ATTACH (17,"75349/T2DA$",3,0,,)
0160  CALL ATTACH (18,"75349/T2DB$",3,0,,)
0170  CALL ATTACH (19,"75349/T3A$",3,0,,)
0180  CALL ATTACH (20,"75349/T3B$",3,0,,)
0190  CALL ATTACH (21,"75349/T3PA$",3,0,,)
0200  CALL ATTACH (22,"75349/T3PB$",3,0,,)
0210  CALL ATTACH (23,"75349/T3DA$",3,0,,)
0220  CALL ATTACH (24,"75349/T3DB$",3,0,,)
0230  CALL ATTACH (25,"75349/T1P$",3,0,,)
0240  CALL ATTACH (26,"75349/T1D$",3,0,,)
0250  CALL FMEDIA (13,5)
0260  CALL FMEDIA (14,5)
0270  CALL FMEDIA (15,5)
0280  CALL FMEDIA (16,5)
0290  CALL FMEDIA (17,5)
0300  CALL FMEDIA (18,5)
0310  CALL FMEDIA (19,5)
0320  CALL FMEDIA (20,5)
0330  CALL FMEDIA (21,5)
0340  CALL FMEDIA (22,5)
0350  CALL FMEDIA (23,5)
0360  CALL FMEDIA (24,5)
0370  CALL FMEDIA (25,5)
0380  CALL FMEDIA (26,5)
0390C LINES 410 THROUGH 430 READ IN TEMP DATA FOR ALL
0400C FAILURES AND CONVERT DATE/TIMES TO "YEAR HOURS".
0410  DO 10 I=1,6391
0420  READ(11,101)A(1),A(2),A(3)
0430  101 FORMAT (V)
0440  B=(A(1)-1)*24+A(2)
0450C T(B) EQUALS THE TEMPERATURE FOR A GIVEN
0460C YEAR HOUR.
0470  T(B)=A(3)
0480  10 CONTINUE
0490C LINES 510 THROUGH 530 READ IN ALL THE DATA
0500C CONTAINED IN THE FILE CLSC2.
0510  DO 11 J=1,159
0520  READ(12,102)(C(K),K=1,10)
0530  102 FORMAT (V)
```

```
0540C LINES 570 THROUGH 620 SET VARIABLES D(1) - D(5)
0550C EQUAL TO TBSF,WD,WS,PRESS,AND HUMIDITY.
0560C F(1) EQUALS TEMP AT FAILURE.
0570  D(1)=C(1)
0580  D(2)=C(5)
0590  D(3)=C(6)
0600  D(4)=C(7)
0610  D(5)=C(8)
0620  F(1)=C(4)
0630C LINES 660 THROUGH 1560 COMPUTE THE AVERAGE
0640C TEMPERATURE IN SIX HOUR INCREMENTS FROM SIX HOURS
0650C TO 72 HOURS PRECEEDING FAILURE.
0660  DO 12 K=1,6
0670  F(1)=F(1)+T(C(3)-K)
0680  12 CONTINUE
0690  F(2)=F(1)
0700  DO 13 L=7,12
0710  F(2)=F(2)+T(C(3)-L)
0720  13 CONTINUE
0730  F(3)=F(2)
0740  DO 14 M=13,18
0750  F(3)=F(3)+T(C(3)-M)
0760  14 CONTINUE
0770  F(4)=F(3)
0780  DO 15 N=19,24
0790  F(4)=F(4)+T(C(3)-N)
0800  15 CONTINUE
0810  F(5)=F(4)
0820  DO 16 II=25,30
0830  IF ((C(3)-II).GT.0.) GO TO 30
0840  Z=T(8760+(C(3)-II))
0850  GO TO 31
0860  30 Z=T(C(3)-II)
0870  31 F(5)=F(5)+Z
0880  16 CONTINUE
0890  F(6)=F(5)
0900  DO 17 IJ=31,36
0910  IF ((C(3)-IJ).GT.0.) GO TO 32
0920  Z=T(8760+(C(3)-IJ))
0930  GO TO 33
0940  32 Z=T(C(3)-IJ)
0950  33 F(6)=F(6)+Z
0960  17 CONTINUE
0970  F(7)=F(6)
0980  DO 18 IK=37,42
0990  IF ((C(3)-IK).GT.0.) GO TO 34
1000  Z=T(8760+(C(3)-IK))
1010  GO TO 35
1020  34 Z=T(C(3)-IK)
1030  35 F(7)=F(7)+Z
1040  18 CONTINUE
1050  F(8)=F(7)
1060  DO 19 IL=43,48
```

```
1070  IF ((C(3)-IL).GT.Ø.) GO TO 36
1080  Z=T(8760+(C(3)-IL))
1090  GO TO 37
1100  36 Z=T(C(3)-IL)
1110  37 F(8)=F(8)+Z
1120  19 CONTINUE
1130  F(9)=F(8)
1140  DO 20 IM=49,54
1150  IF ((C(3)-IM).GT.Ø.) GO TO 38
1160  Z=T(8760+(C(3)-IM))
1170  GO TO 39
1180  38 Z=T(C(3)-IM)
1190  39 F(9)=F(9)+Z
1200  20 CONTINUE
1210  F(1Ø)=F(9)
1220  DO 21 IN=55,60
1230  IF ((C(3)-IN).GT.Ø.) GO TO 40
1240  Z=T(8760+(C(3)-IN))
1250  GO TO 41
1260  40 Z=T(C(3)-IN)
1270  41 F(10)=F(1Ø)+Z
1280  21 CONTINUE
1290  F(11)=F(10)
1300  DO 22 JJ=61,66
1310  IF ((C(3)-JJ).GT.Ø.) GO TO 42
1320  Z=T(8760+(C(3)-JJ))
1330  GO TO 43
1340  42 Z=T(C(3)-JJ)
1350  43 F(11)=F(11)+Z
1360  22 CONTINUE
1370  F(12)=F(11)
1380  DO 23 JK=67,72
1390  IF ((C(3)-JK).GT.Ø.) GO TO 44
1400  Z=T(8760+(C(3)-JK))
1410  GO TO 45
1420  44 Z=T(C(3)-JK)
1430  45 F(12)=F(12)+Z
1440  23 CONTINUE
1450  D(6)=F(1)/7.
1460  D(7)=F(2)/13.
1470  D(8)=F(3)/19.
1480  D(9)=F(4)/25.
1490  D(1Ø)=F(5)/31.
1500  D(11)=F(6)/37.
1510  D(12)=F(7)/43.
1520  D(13)=F(8)/49.
1530  D(14)=F(9)/55.
1540  D(15)=F(1Ø)/61.
1550  D(16)=F(11)/67.
1560  D(17)=F(12)/73.
1570C LINES 16ØØ THHROUGH 166Ø COMPUTE THE AVERAGE
1580C RATE OF TEMPERATURE CHANGE FROM ONE HOUR
1590C TO 12 HOURS PRIOR TO FAILURE.
```

```
1600  E(1)=ABS(C(4)-T(C(3)-1))
1610  DO 24 JL=2,12
1620  E(JL)=E(JL-1)+ABS(T(C(3)-(JL-1))-T(C(3)-JL))
1630  24 CONTINUE
1640  DO 25 JM=1,12
1650  G(JM)=E(JM)/JM
1660  25 CONTINUE
1670C LINES 1690 THROUGH 1980 WRITE THE DATA
1680C COMPUTES ABOVE INTO THE FINAL FILES.
1690  WRITE(13,103)(D(JM),JM=1,11)
1700  WRITE(14,103)(D(JN),JN=1,5),(D(KK),KK=12,17)
1710  103 FORMAT(F6.2,1X,F4.0,1X,F3.0,1X,F5.2,1X,
1720  &F3.0,1X,6(F5.1,1X))
1730  WRITE(19,103)(D(KL),KL=1,5),(G(KM),KM=1,6)
1740  WRITE(20,103)(D(KN),KN=1,5),(G(KA),KA=7,12)
1750  I=C(9)
1760  IF(I.LT.1) GO TO 1
1770  IF (C(2).LE.67.5) GO TO 60
1780  D(1)=C(2)-WW
1790  WRITE(25,106)D(1),C(4),(D(WY),WY=2,5)
1800  106 FORMAT(F6.2,2X,F4.0,2X,F4.0,2X,F3.0,2X
1810  &F5.2,2X,F3.0)
1820  WRITE(15,103)(D(KB),KB=1,11)
1830  WRITE(16,103)(D(KC),KC=1,5),(D(KD),KD=12,17)
1840  WRITE (21,103)(D(KE),KE=1,5),(G(KF),KF=1,6)
1850  WRITE(22,103)(D(KG),KG=1,5),(G(KH),KH=7,12)
1860  60 WW=C(2)
1870  GO TO 11
1880  1 JW=C(10)
1890  IF (JW.LT.1) GO TO11
1900  IF (C(2).LE.526.30) GO TO 61
1910  D(1)=C(2)-WX
1920  WRITE(26,106) D(1),C(4),(D(WZ),WZ=2,5)
1930  WRITE(17,103)(D(LA),LA=1,11)
1940  WRITE(18,103)(D(LB),LB=1,5),(D(LC),LC=12,17)
1950  WRITE(23,103)(D(LD),LD=1,5),(G(LE),LE=1,6)
1960  WRITE(24,103)(D(LF),LF=1,5),(G(LG),LG=7,12)
1970  61 WX=C(2)
1980  11 CONTINUE
1990  STOP
2000  END
```

SELECTED BIBLIOGRAPHY

A. REFERENCES CITED

1. Air Force Systems Command, Space and Missile Systems Office. Minuteman Master Schedule, October, 1974.

2. ________. Minuteman Program Management Plan, 15 July 1974.

3. ________. Minutes Minuteman Integrated Deployment Planning Scheduling Meeting, 7 May 1974.

4. Air Training Command, Chanute Technical Training Center. Study Guide 30BR3121G-4-SG-310A, Minuteman Electronics Branch, 20 November 1972.

5. ________. Study Guide 3ABR31606-1-SG-706, Missile Analyst Branch, 15 February 1972.

6. ________. Study Guide 3ABR31630H-SG-706 and 30ZR2825-2-SG-106, Missile Analyst Branch, 24 April 1972.

7. ________. Study Guide 3ABR31630G-1-56-802, Missile Analyst Branch, 7 August 1972.

8. ________. Study Guide 3ABR31630G-1-56-1103, Missile Analyst Branch, 7 August 1972.

9. ________. Programmed Text 30BR3121G-4-PT-109, Missile Maintenance Officer, WS-133, 9 May 1973.

10. Boyett, Joseph E., Lt. Col. Assistant Professor of Logistics Management, Management Studies Department, School of Systems and Logistics, Air Force Institute of Technology. Personal interview. 11 July 1975.

11. Clark, Lt. Thomas. 3 Weather Wing, Detachment 15, Grand Forks AFB, North Dakota. Telephone interview. 2 October 1974.

12. Dede, Lt. Col. Vern. Strategic Air Command/LGBM, Offutt AFB, Nebraska. Telephone interview. 27 September 1974.

Preceding page blank

13. Genet, Russell M. Chief, Plans and Management Staff Office, Aerospace Guidance and Metrology Center, Newark AFS, Ohio. Telephone interviews. 10 February 1975 through 11 July 1975.

14. Goodwin, Lt. Col. Walton. Chief, Reliability and Quality Assurance Division, SAMSO/MNDR, Norton AFB, California. Telephone interview. 10 February 1975.

15. Gwylliam, Keith. Logistics Specialist, Ogden Air Logistics Center/MER, Hill AFB, Utah. Telephone interview. 24 September 1974.

16. Helmstadter, G. C. Research Concepts in Human Behavior. New York: Appleton-Century-Crofts, Education Division, Meredith Corporation, 1970.

17. Henderson, Stephen, Captain. Assistant Professor of Logistics Management, Quantitative Studies Department, School of Systems and Logistics, Air Force Institute of Technology. Personal interview. 10 July 1975.

18. Howard, J. H., and P. M. Steele. Business Control Through Multiple Regression Analysis. New York: John Wiley and Sons, 1973.

19. Neukuckatz, A. TRW Representative, Reliability and Quality Assurance Division, SAMSO/MNDR, Norton AFB, California. Telephone interviews. 26 September and 4 October 1974.

20. Pirtle, Major Paul. SAMSO/MNNG, Norton AFB, California. Telephone interview. 17 October 1974.

21. Schaefer, Major Joseph D. Maintenance Supervisor, 321 Strategic Missile Wing, Grand Forks AFB, North Dakota. Telephone interviews. 3-7 December 1974.

22. Saucier, Walter J. Principles of Meteorological Analysis. Chicago: University of Chicago Press, 1955.

23. Turbin, Carroll. Autonetics representative, Offutt AFB, Nebraska. Telephone interviews. 28 September-2 October 1974.

24. U.S. Department of the Air Force. Equipment Maintenance Policies, Objectives and Responsibilities, AFR 66-14, Strategic Air Command Supplement 1, 5 February 1973.

25. ________. Missile Guidance Control System AN/DJW-47 Alignment and Targeting Procedures. Technical Order 21M-LGM30G-2-12, 5 August 1970.

26. University of California at Los Angeles, Health Science Computing Facility. Biomedical Computer Programs. University of California Press, 1970.

27. Wallan, Robert. Reliability Engineer, Ogden Air Logistics Center/MER. Telephone interview. 28 September 1974.

28. Williams, E. J. Regression Analysis. New York: John Wiley and Sons, 1959.

29. Willis, Raymond E., and Norman L. Chervany. Statistical Analysis and Modeling for Management Decision Making. Wadsworth Publishing Company, Inc., Belmont, California, 1974.

30. Wonnacott, Thomas H., and Ronald J. Wonnacott. Introductory Statistics for Business and Economics. New York: John Wiley and Sons, 1972.

B. RELATED SOURCES

Air Force Institute of Technology, School of Systems and Logistics. Style and Guidance Manual for Theses and Technical Reports, Research and Communicative Studies Department. 4th rev. May 1974.

Air Training Command, Chanute Technical Training Center. Study Guide 3ABR443306-2-PT-108, Missile Analyst Branch, 3 October 1972.

Ballou, Stephen V., and William G. Campbell. Form and Style, Theses, Reports, Term Papers. Boston, Mass: Houghton Mifflin Company, 1974.

Conover, W. J. Practical Nonparametric Statistics. New York: John Wiley and Sons, 1971.

Fletcher, Lt. Col. Jack. Strategic Air Command Liaison Office, Ogden Air Logistics Center, Hill AFB, Utah. Telephone interview. 24 September 1974.

Martin, Richard. Aerospace Guidance and Metrology Center, Newark AFS, Ohio. Telephone interview. 24 September 1974.

Osgood, Major James. Strategic Air Command/XPQM, Offutt AFB, Nebraska. Telephone interview. 24 September 1974.

Weber, Major Richard. Strategic Air Command Systems Office, Norton AFB, California. Telephone interview. 27 September 1974.